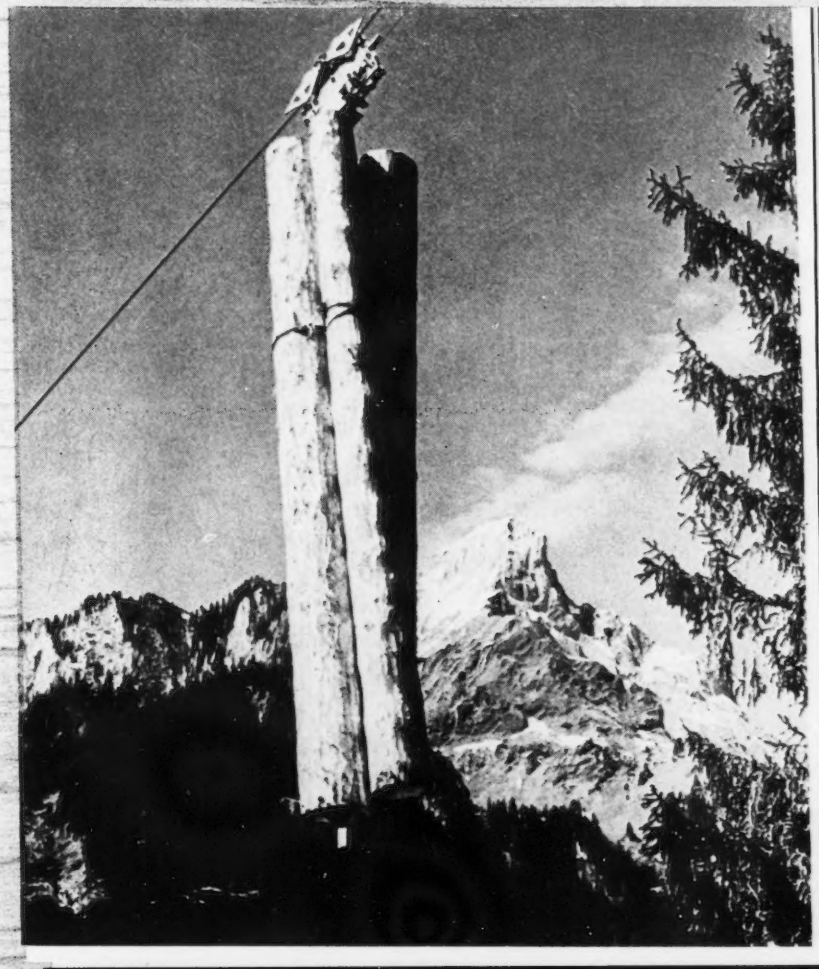
FOREST PRODUCTS JOURNAL

FOREST PRODUCTS RESEARCH SOCIETY



INDUSTRIAL PROGRESS ISSUE

Logging p. 49

Lumber Manufacturing p. 53

Wood Drying p. 55

Glues and Gluing p. 77

Chemical Conversion p. 85

Wood Preservation p. 67

* * *

Plus: Crystallinity of Wood Fibers p. 108

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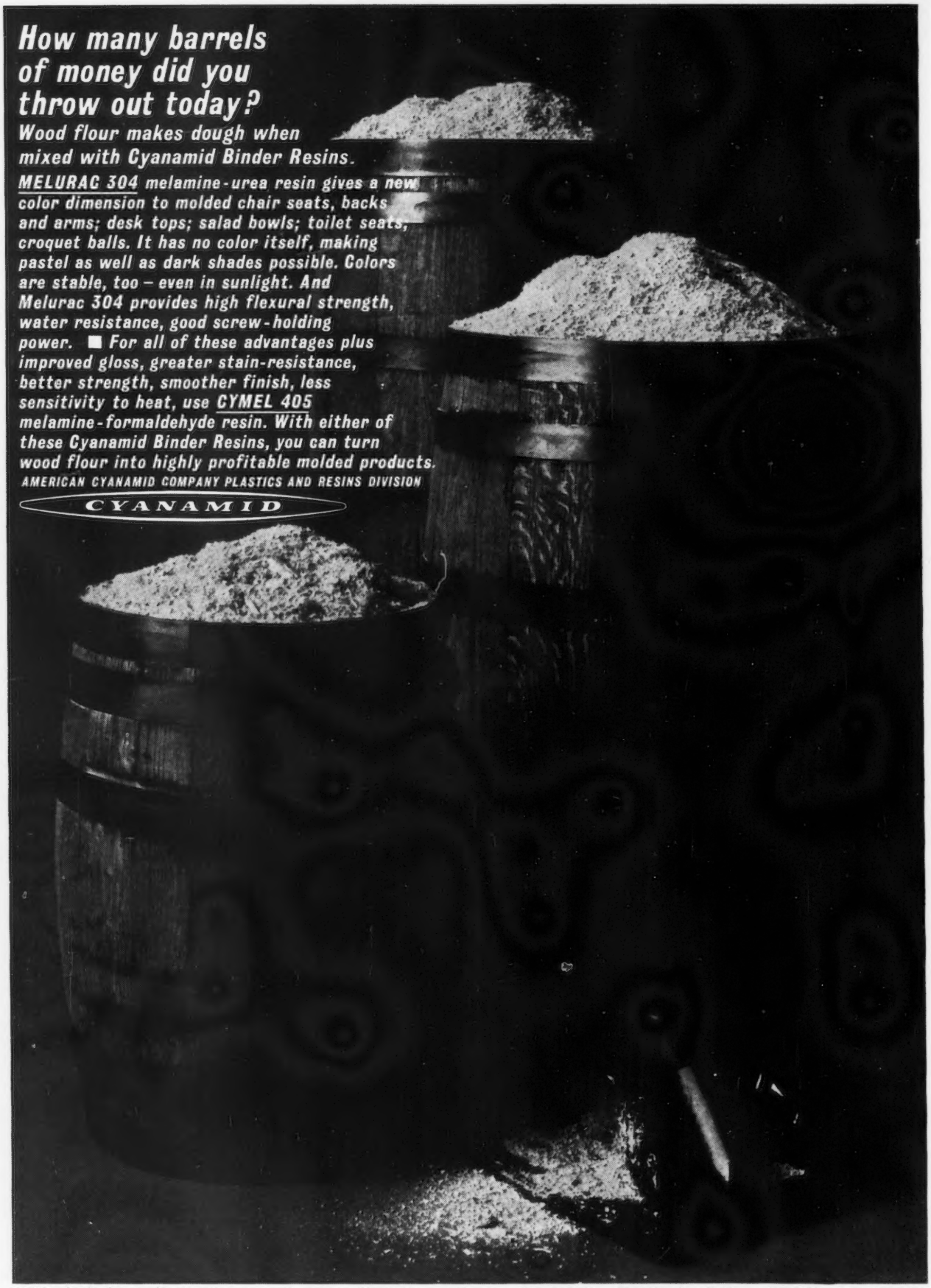
Cover: Skyline Logging in British Columbia

Vol. XI, No. 2

1961 / FEBRUARY


How many barrels of money did you throw out today?
Wood flour makes dough when mixed with Cyanamid Binder Resins.
MELURAC 304 melamine-urea resin gives a new color dimension to molded chair seats, backs and arms; desk tops; salad bowls; toilet seats, croquet balls. It has no color itself, making pastel as well as dark shades possible. Colors are stable, too – even in sunlight. And Melurac 304 provides high flexural strength, water resistance, good screw-holding power. ■ For all of these advantages plus improved gloss, greater stain-resistance, better strength, smoother finish, less sensitivity to heat, use CYMEL 405 melamine-formaldehyde resin. With either of these Cyanamid Binder Resins, you can turn wood flour into highly profitable molded products.
AMERICAN CYANAMID COMPANY PLASTICS AND RESINS DIVISION
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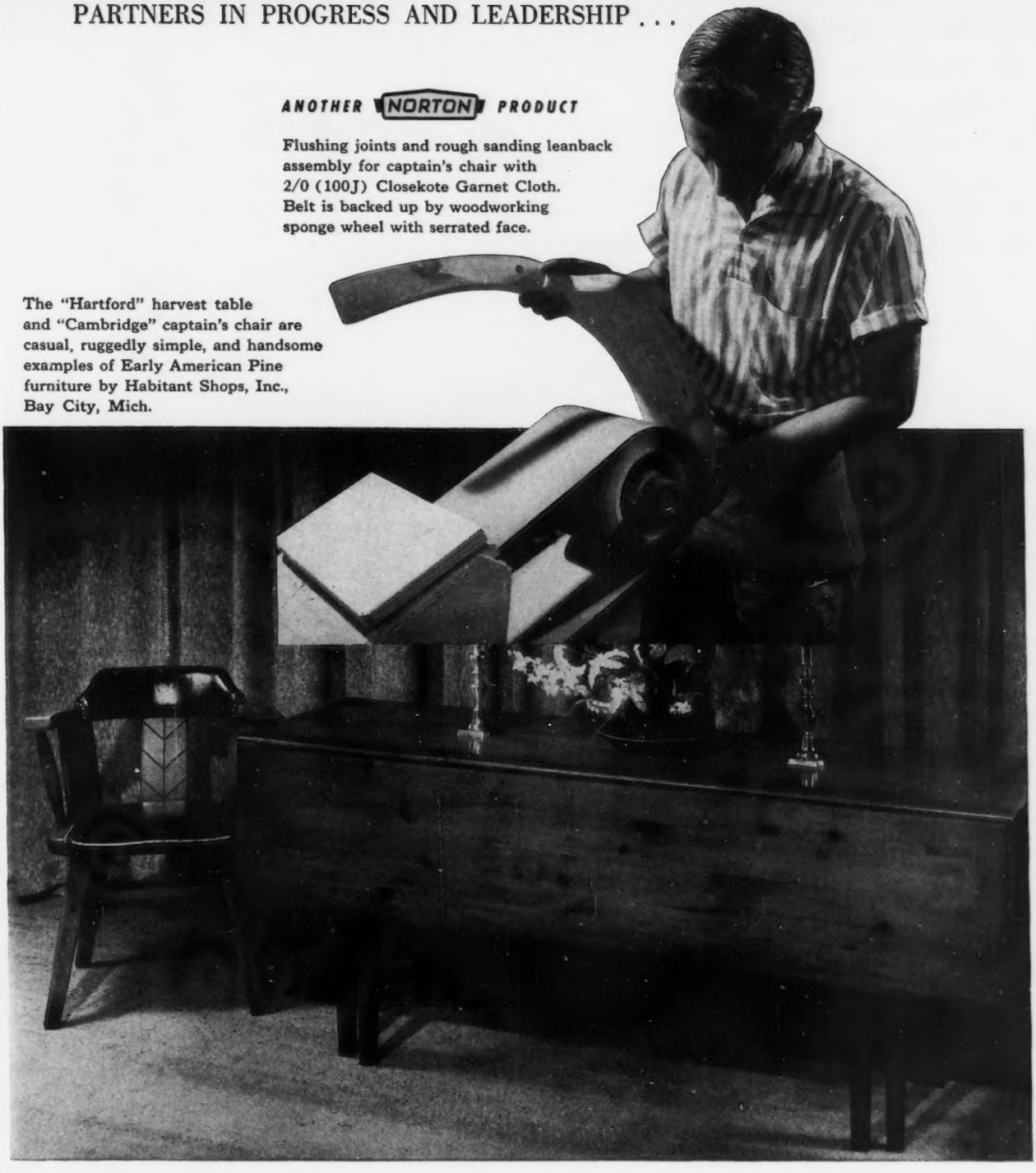
See Reader Service Form, page 22-A.

PARTNERS IN PROGRESS AND LEADERSHIP . . .

ANOTHER NORTON PRODUCT

Flushing joints and rough sanding leanback assembly for captain's chair with 2/0 (100J) Closekote Garnet Cloth. Belt is backed up by woodworking sponge wheel with serrated face.

The "Hartford" harvest table and "Cambridge" captain's chair are casual, ruggedly simple, and handsome examples of Early American Pine furniture by Habitant Shops, Inc., Bay City, Mich.



Sanding with Garnet Cloth

is the first step to a finish that sparkles with customer-appeal. And the best step toward solving a sanding problem is to call on the same "Abrasive Tech" service which recommended the installation above. Just contact your nearest Behr-Manning office, or write Dept. FP-2, BEHR-MANNING Co., Troy, N. Y., a division of Norton Company.

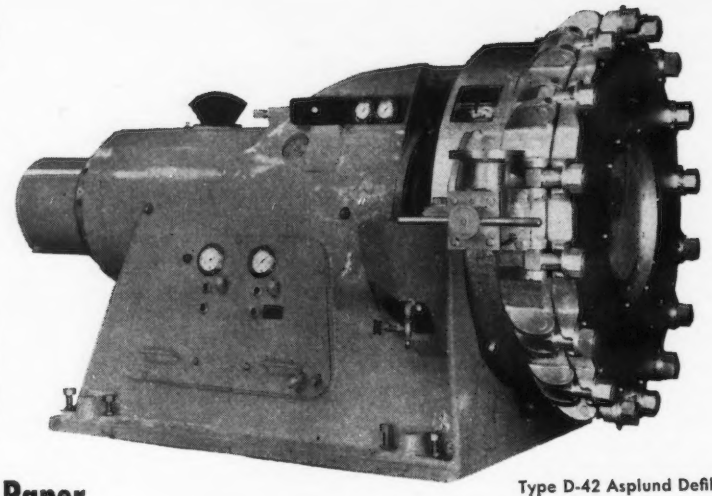
BEAR BRAND Abrasives

Continuous Pulping for Wallboard — Roofing Felt

The **Asplund** Defibrator is used for continuous pulping of wood chips and other cellulose raw materials for the production of hardboard, softboard, roofing and flooring felt.

Continuous Semi-Chemical Pulping

The Defibrator continuous digester produces semi-chemical pulp for corrugating board and other types of paper products using wood chips as raw material as well as bagasse, straw, and cotton linters. The Defibrator Continuous Digester is also used for chemical extraction of bark materials.



Type D-42 Asplund Defibrator

Asphalt Dispersion — Waste Paper

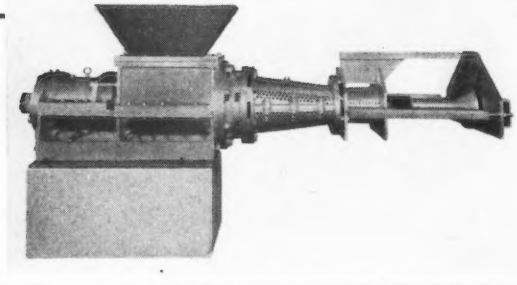
Waste paper containing asphalt, waxes, and similar materials are processed through the "A-D" System for dispersion of the asphalt and related materials. As a result, a clean, sterile sheet is made on the paper machine, at considerable savings, since less expensive waste paper can be utilized.
Combined annual capacity now installed in nearly two million tons of waste paper.

New L-36 Asplund Defibrator

Conservatively rated at 60 tons of hardboard fiber per day. Also used for semi-chemical pulping and asphalt dispersion processes with capacity up to 150 tons per day. Operates with maximum steam pressure of 180 psi; grinding pressure regulated hydraulically from control panel; level of material in digester electronically controlled with gamma rays; designed for easy replacement of grinding segments.

New D-42 Asplund Defibrator

Developed to meet the current trend in the Pulp and Paper industry towards larger production units. Those now in operation indicate capacity of about 100 tons per day of non-chemical, and 200 or more per day of semi-chemical pulp.

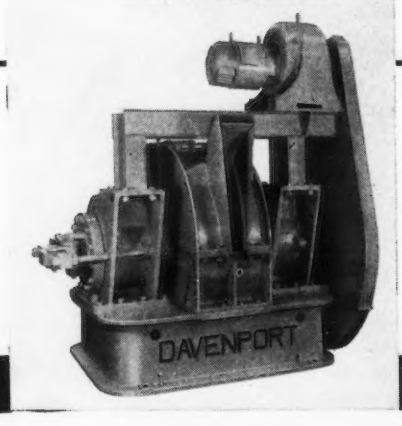


The Defibrator Bark Press

The Defibrator Bark Press was developed for continuous dewatering of bark for use as fuel. Processing capacity is approximately 5 tons per hour (on a b.d. basis), and power consumption at this rate runs between 60 and 75 H.P.

The Davenport Dewatering Press

The Davenport Continuous Press expels water from white pulp including repulped waste paper. The process is efficient and completely mechanical, with low power consumption and high capacity. Maintenance costs are exceptionally low.



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Mercer Island, Washington

See Reader Service Form, page 22-A.

Let National Casein help you PROLONG THE LIFE OF YOUR WOOD PRODUCTS

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water repellent preservative protects wood from destructive insects, rot and stain . . . imparts water repellency to wood.

Woodtrol (WRL)

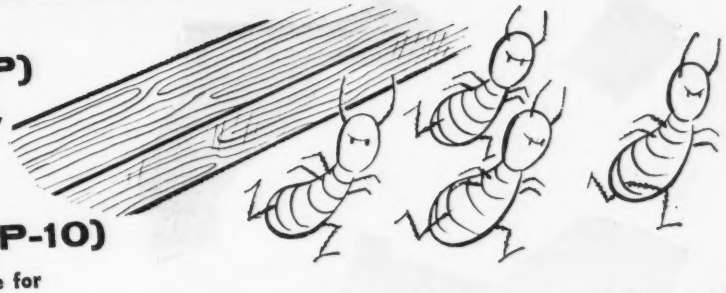
water repellent lubricant reduces friction between moving wood parts and makes wood water repellent.

Woodtrol (P)

preservative for millwork, furniture and structural lumber.

Woodtrol (P-10)

Woodtrol (P) concentrate for large quantity users.



"That lumber's too highly seasoned for us!"

YOUR "NATIONAL CASEIN" GLUE MAN HAS NEWS FOR YOU

In addition to helping you determine the right glue for your job—the "National Casein" man who calls on you is now equipped to help you protect your wood products against deterioration from mechanical wear, moisture, mildew, rot, stain and from insects. "National Casein's" Woodtrol series of wood protectors is helping the furniture, millwork and structural lumber industries to prolong the life, beauty and usefulness of their wood products and wood construction. Write for data, prices, samples. Ask the "National Casein" man who calls on you about Woodtrol wood protection, or contact the office nearest you. No obligation to purchase.

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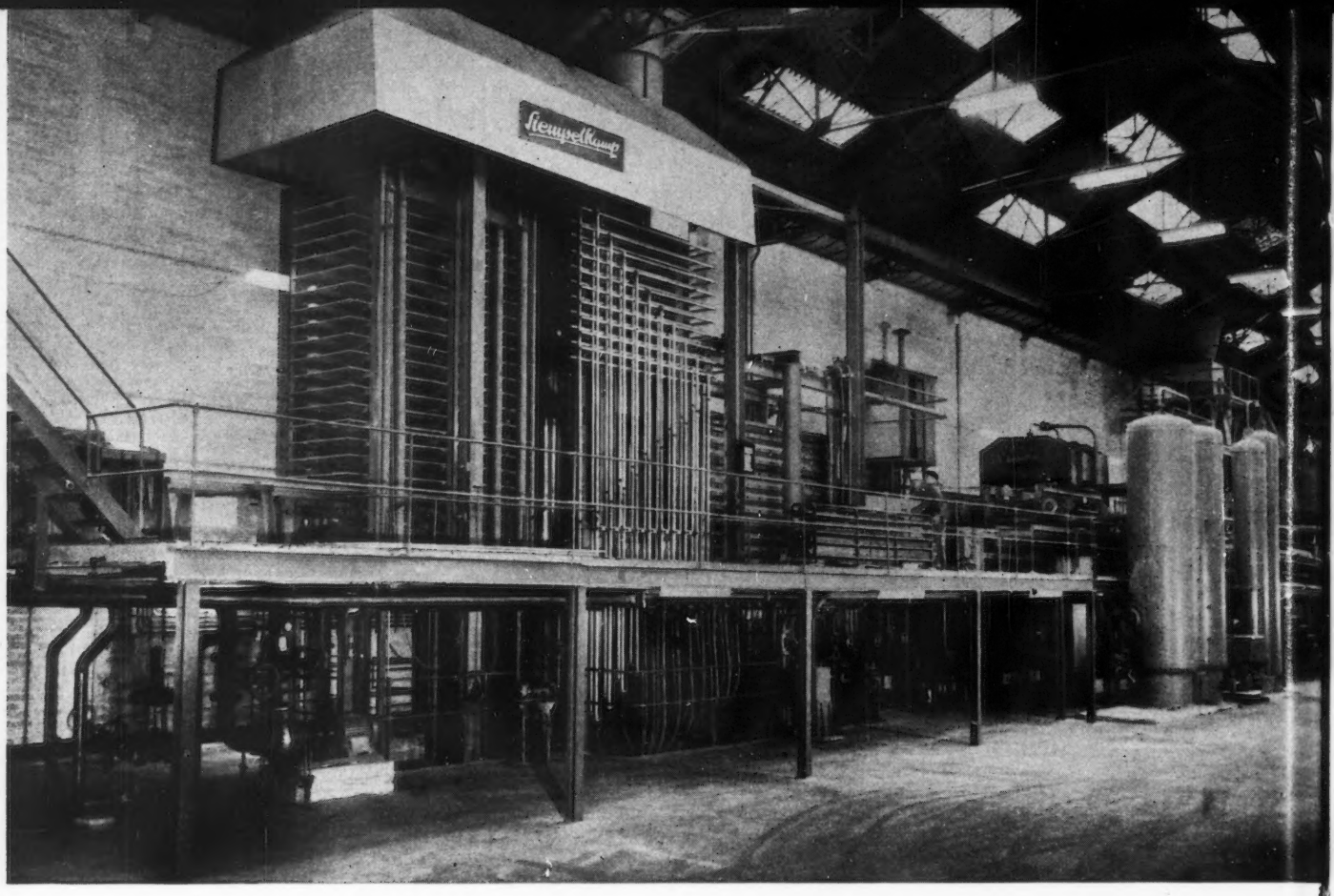

Automatic press plant of Messrs. Linex - Belgium

Chip Board and Particle Board Press installation

suitable for:

- All Types of applicable raw materials
- All Manufacturing processes
- All Stages of automation
- All required capacities

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FOREST PRODUCTS JOURNAL

Vol. XI, No. 2 February, 1961

CONTENTS

1960 ANNUAL REVIEWS

		Page
Progress in Logging—1960	*J. A. Doyle*	49
Lumber Manufacturing—1960	*J. L. Barrow, Jr.*	53
Progress in Wood Drying—1960	*E. L. Ellwood*	55
Progress in Wood Preservation, 1959–1960	*H. E. Troxell*	67
Progress in 1960—Glues and Gluing Processes	*R. F. Blomquist*	77
A Review of Progress in Chemical Conversion	*J. W. Rowe* and *I. A. Pearl*	85

FIBER PROPERTIES

Crystallinity of Wood Cellulose Fibers Studied by X-Ray Methods	*C. L. Lee*	108

DEPARTMENTS

News Digest	7-A
President's Message	9-A
Cross Section	12-A
Abstracting the Literature	113
Names in the News	21-A
Employment Opportunities	21-A
Advertisers' Index	21-A
Reader Service Card	22-A

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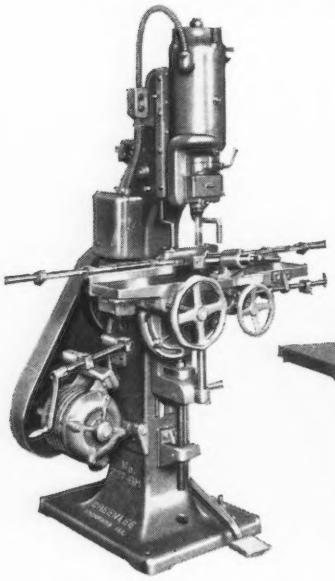
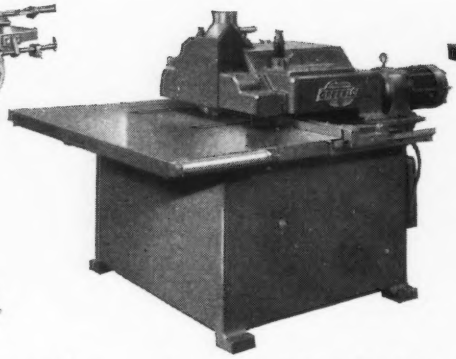
WMMA — WOODWORKING MACHINERY MANUFACTURERS ASSOCIATION

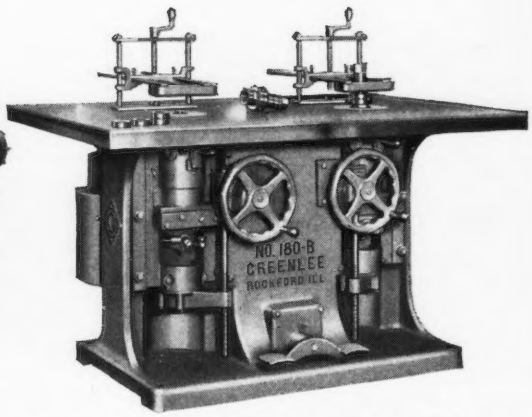
WRITE FOR CATALOG W-504-A



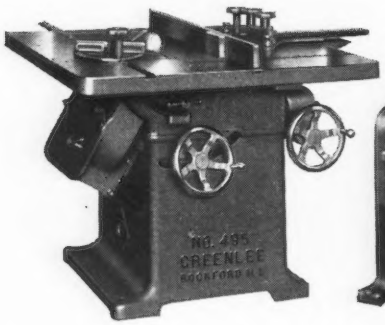
No. 227-BM Vertical Hollow-Chisel Mortiser Well-known for its accuracy, speed and economical operation. Variable feed provides wide range of strokes-per-minute in hard or soft wood. No. 212 Horizontal Multiple-Spindle Mortiser available for big-volume production.



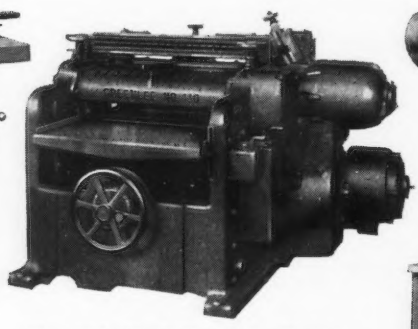
No. 431 Roll-Feed Rip Saw Provides fast, accurate, full-powered ripping. Reduces waste to a minimum. Cuts straight or parallel to curvature of stock. Arbor motor and power feed rolls are mounted above table. Vertical arbor adjustment.



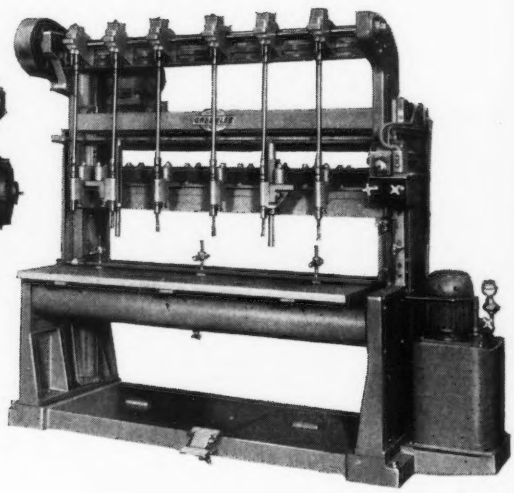
No. 180-B Double-Spindle Shaper High-speed spindles run in opposite directions for greater versatility. Belted motor drive on each spindle eliminates need for frequency changer. Precision ball bearings lubricated for longer life.



No. 495 Tilting-Arbor Variety Saw Quickly set up for production runs. Rigid table assures precision cuts. Built in motor and blade are assembled as a single unit which lowers, raises and tilts 45°. Cast-iron base for extra rigidity.



No. 110 Six-Roll Single Planer Designed to produce a high quality finish and maintain precise dimensions. Head is mounted in large, precision bearings. Four speed feed motor for 25-40-50 and 80 f.p.m. Increased feed rates and head speeds available to meet unusual requirements.



No. 308 Hydraulic Feed Gang Borer Stationary table provides maximum precision, production and work convenience. Variable hydraulic feed simplifies operation, increases production and gives precise control at all times. Smooth. Quiet. Available in 4, 6, and 8 foot sizes.

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SINCE 1863

1972 TWENTY-FIRST AVE.
ROCKFORD, ILLINOIS

TRANSFER MACHINES • SPECIAL MACHINES • AUTOMATIC BAR MACHINES • WOODWORKING MACHINES AND TOOLS • DIE CASTING MACHINES • TRIM PRESSES • HYDRAULIC AND HAND TOOLS

See Reader Service Form, page 22-A.

CONVENTION HEADQUARTERS

Headquarters for the 15th Annual Meeting of FPRS will be the Kentucky Hotel, Louisville, Ky. Make your reservations now.

FPRS News-Digest

Inland Empire Plans Meet With Wood Products Clinic

The Inland Empire Section of the Forest Products Research Society and the Northwest Wood Products Clinic will hold their annual combined meeting at the Davenport Hotel, Spokane, Wash., on April 11 and 12. The theme will be "The Future of Our Industry". Mr. Ernst W. Hammerschmidt, Lombard, Ill., Hoo Hoo Snark of the Universe, will be a principal speaker.

Above are members of the committee planning the meeting. Seated, l. to r.; Robert A. Crowe, Missoula White Pine Sash Company, FPRS program chairman; and John L. Ailport, Anaconda Company, N.W.P.C. program chairman; standing, l. to r., Robert J. Hoyle, Jr. Potlatch Forests, Inc., FPRS section chairman; and Steele Barnett, Boise Cascade Corporation, N.W.P.C. President.

Official Rules Announced For Wood Awards

Dr. Eric Anderson, Chairman of the F.P.R.S. Industry-Education Committee, and J. F. Koellisch, editor and publisher of *Wood & Wood Products,* have jointly announced the official rules for the 12th annual Wood Awards competition. The awards will be presented at the Society's Annual Meeting in Louisville, Ky., June 18–22.

Consistent with the basic aims of the Wood Awards competition, original research papers are invited from all graduate students attending any North American university or college for at least one quarter or semester between January 1, 1960, and April 30, 1961. Tentative titles must be submitted to the FPRS Executive Secretary, K. E. Huddleston, by April 1 and all entries must be in his hands by April 25.

First award is $350 cash and a certificate of merit. The second award consists of $150 in cash and a certificate. The first award winner will be requested to present his paper at the Louisville meeting. Names of judges and other details will be published later.

Meet FPRS Supporting Member... Snellstrom Lumber Co., Eugene, Ore.

Aerial view of Snellstrom Lumber Co., Eugene, Ore.

Snellstrom

One of the newest FPRS Supporting Members is the Snellstrom Lumber Company, Eugene, Ore., represented by Gerald C. Snellstrom, vice president.

Son of the late Charles Snellstrom, founder and former president, Mr. Snellstrom has worked in and around the plant since high school days, gaining experience in every phase of the operation. Beginning with the green chain, he has worked through the planing and sawmill plants, in the plywood mill, and 18 months in the woods operation at Elton, Ore. After 2 years in the sales department, he is now in charge of general administration, with special attention to sales promotion, new products and technology, finance, and cost information that contributes to improved efficiency and lower cost. Educated at Shattuck Military Academy and the University of Oregon, Mr. Snellstrom is married and has a son and a daughter.

Snellstrom Lumber Co. began business on March 28, 1950, when it purchased the Eugene Lumber Co. Subsequent purchases have added four mills and substantial timber holdings.

A continuing program of plant improvement has been carried on, and the company now has sawmill and planing mill facilities with a total capacity of 1,500,000 board feet per month. Special lumber items include cutting stock, dimension and small squares.

The company began the manufacture of plywood in 1952, and now operates a complete manufacturing plant. This covers 104,000 square feet, and has a capacity of 6 million feet of hot pressed plywood a month. Items include Texture One-Eleven, 2.4.1 flooring panels, exterior and interior sanded panels, and sheathing.

Operated in connection with the plywood mill is a chipping and hogging installation which provides complete utilization of the logs.

During the past 10 years, Snellstrom Lumber Co. has made substantial progress. Since 1951, its assets have increased from $683,000 to over $8 million. Sales have increased from $1,075,000 to over $6 million in the past decade, and the number of employees has increased from 75 to 340. The net worth has been multiplied 8½ times.

FPRS welcomes the Snellstrom Lumber Co. into its ranks of forward-looking Supporting Members.

 See Reader Service Form, page 22-A.

Anderson

Reno

Anderson Elected To New York Academy

Dr. Arthur B. Anderson, chief of the Division of Forest Products Chemistry in the University of California's Forest Products Laboratory at Richmond, has been elected a member of the New York Academy of Sciences. He was honored for his outstanding contributions to the field of wood chemistry and forest products utilization.

Anderson is widely-known for his successful research on the use of wood residues as commercial chemical products, the influence of extractives on wood properties, and the chemical drying of lumber. He has been granted many patents for his discoveries of new processes for treating and using woods, and has written extensively for the *Forest Products Journal* and other scientific journals on his work.

Protected Exteriors Described By Reno

Protected exterior finishes are described in three releases by John Reno, The Pacific Lumber Co., Chicago. Entitled "Protection Against Termites," "Prevent Paint Blisters and Stains on Exteriors," and "Trouble-Free Siding," these articles are composites of manuscripts by the author which appeared in many national trade journals in recent months.

"Protection Against Termites" explains how termite-proof houses can be built economically, and discusses houses with basements, crawl spaces, and concrete slab floors on the ground. "Prevent Paint Blisters and Stains on Exteriors" gives 37 recommendations to builders so that they may prevent these problems. "Trouble-Free Siding" begins with a range of moisture content of 9 to 14 percent for all patterns of house siding in most parts of the U.S. and Canada. It includes bevel siding, drop siding or rustic siding, board and batt, and board and board.

George B. Amidon Named Greeley Lecturer

The appointment of George B. Amidon, Director of Woodlands, Minnesota and Ontario Paper Co., International Falls, Minn., as the 1961 William B. Greeley Lecturer in Industrial Forestry has been announced by Dean Gordon D. Marckworth, University of Washington College of Forestry. Mr. Amidon's lectures will be the fifth in the series, made possible through a grant from the Industrial Forestry Association as a memorial to the late Colonel William B. Greeley.

Mr. Amidon will present a series of three lectures on the Development of Industrial Forestry in the Lake States on March 2, 3, and 4 on the University of Washington campus.

Decar Plastic Corporation Adds to Technical Staff

T. Walter Nobel, vice president and technical director of Decar Plastics Corporation, has announced the addition of three specialists to Decar's technical staff.

Robert Lyon, who has more than 8 years experience in the plastics industry, has been named laboratory director. He will report directly to Nobel. In addition to overall supervision of the laboratories, Lyon will be responsible for quality control of Decarlite, the high-pressure plastic laminate produced by Decar.

Lyon

Weslowski

Rash

Martin Weslowski, an analytical chemist, will work with resins and adhesives, including a continuing analysis of raw materials. Weslowski will also emphasize quality control, both of raw materials and their use and performance in the plastic laminates and finished furniture tops.

James Rash, a wood technologist and research chemist, will work on the development of new wood products. Howecer, he will also concentrate on quality control of completed furniture tops, with a direct interest in control of moisture content and related problems, such as warpage and shrinkage.

"While the Decar Corporation has always been concerned with quality control, the three new staff members mean that more time can be devoted to new materials. Their efforts will be directed towards bringing the newest developments to Decar's customers at the lowest possible cost of materials needed to yield the desired performance," Nobel said.

Decar, a long-time supporting member of FPRS, has laboratory and production facilities at Middleton, Wis., a few miles from the Society's National Office.

Lignin Research Grant Renewed

Commercial utilization of lignin may be advanced by renewal of a grant of $9600 to the Oregon Forest Research Center, Corvallis, Ore. The grant was made by the Louis W. and Maud Hill Family Foundation to support basic research in lignin.

D. W. Glennie, Chief of Chemical Division of Forest Products Research, stated that the grant will make possible continued studies of chemical structure of lignin, studies which were initiated in 1959 through a grant from the Hill Family Foundation and its South Santiam Educational and Research Project. Red alder was selected as the species of wood to study because it is a native hardwood with lignin not so difficult to study. Most research in forest products at the center is financed by a tax on timber harvested in Oregon.

Particleboard Group Meets in D. C.

Plans for an accelerated promotion program and development of standards were formulated by the National Particleboard Association at its annual meeting January 10–11 in Washington, D. C. The association, comprised of 16 manufacturers of particleboard from coast-to-coast, was formed a year ago with headquarters in Washington, D. C. to develop industry-wide standards and promote public acceptance of particleboard in homes, commercial buildings, furniture, kitchen cabinets and other applications. N. P. A. officials also outlined plans for gathering statistics on the industry as a whole. A program for liaison with related trade groups also won approval.

Richmond Gray of Gray Products Company, Waverley, Va., was elected President of the Association succeeding D. C. Greeley of the Weyerhaeuser Company, Tacoma, Wash. Other new officers are William H. Cooke, Pacqua Inc., Dillard, Ore., Vice President; C. G. Reiter, Formica Corporation, Cincinnati, Ohio, Secretary. Richard L. Rinde was re-elected Treasurer.

Named to the Board of Directors were F. L. Foval, International Paper Co., Long-Bell Division, Longview, Wash.; K. N. Stordalen, Wynnewood Products Co., Dallas, Tex.; and J. E. Clark, Brownsville Particleboard and Associated Products Inc., Brownsville, Ore.

Panshin Reports MSU Scholarship Program

A new program of freshmen and sophomore scholarships has been announced by Dr. A. J. Panshin, Head of the Department of Forest Products of Michigan State University. The money was donated by Chapman Chemical Company of Memphis, Tennessee. Two freshmen are to be selected each year to receive $300 each. When they become sophomores they will receive $200 each. These will be offered for the first time to entering freshmen in the fall of 1961.

"We hope promising young men will be encouraged to enter the field of forest products by these scholarships", said Dr. Panshin. "A great number of graduates are needed to fill the demands of the lumber and wood products industries for technically trained people than we can meet with present enrollment," he added.

Wood Utility Pole Group To Meet at N.C. State

The Wood Products Department of the School of Forestry is sponsoring "The South Atlantic Wood Utility Pole Conference" at the campus of the North Carolina State College, Raleigh, N. C. April 5 and 6. Outstanding industry and research people will present basic technology and current information on the production, preservative treatment, purchasing, inspection and maintenance of utility poles.

The conference will be of interest and value to pole producers, preservative treaters and manufacturers, inspectors and the customers and users of wood utility poles, as well as personnel in operating utilities and in the forest products field.

See Reader Service Form, page 22-A.

A Message from the President

. . . Raymond H. Berry

R. H. Berry

THE RAPIDLY PASSING AND EVER-CHANGING pageant of the years is bringing the Forest Products Research Society this June to its Fifteenth Annual Meeting. It is a far different Society, in a far different world, from that which first met fifteen years ago. Imagination falters at any attempt to visualize the nature of the Society and of the world in which it will hold its Annual Meeting fifteen years hence. In the meantime, we shall just have to keep plugging along at our program of making FPRS the outstanding organization in the field of wood, and using it to make known the findings of basic and applied research to spread knowledge and improve the techniques and products of the industry.

The celebration of our fifteenth anniversary is being prepared in the land of Daniel Boone, thoroughbred horses, beautiful women and bourbon whiskey. The city of Louisville, Kentucky, is waiting eagerly to welcome the members of FPRS for the meeting. An active committee, under the leadership of Carl Trinkle, has been working industriously to plan the details of a gathering which will combine technical enlightenment and social diversion. One of the most agreeable things about our FPRS Annual Meetings is the way they provide an opportunity for our members to visit the historic cities of the continent. Louisville, grown from an Ohio River hamlet into a city of prospering and varied industry and a famous cultural center, is one of those historic settlements. In keeping with its history, one of the highlights of the Annual Meeting will be the Paul Bunyan party, which will take place on an Ohio River steamboat, a reminiscence of the great days of travel on American rivers.

The technical program, under the chairmanship of Don Saunders, President Elect of the Society, will be valuable and varied. This, the first such program to be presented under our new Division set-up of process-oriented rather than product-oriented Divisions, will demonstate the practicability of those Divisions and the focussing of interest in the new groupings.

Make your plans now to attend the Louisville meeting and benefit by the wealth of technical advance and informed discussion which will characterize the papers and the panel sessions. And be sure that your plans include bringing your family to visit the Blue Grass State, with its beautiful Ohio and its memory of pioneer days and the building of a nation from the wilderness. Carl Trinkle's committee has plans for your family as well as for you, and Louisville's warm hospitality awaits you all.

Barrow Lumber Company, Ahoskie, N.C., a Southern Pine Mill Mater "42" Riderless Carriage and Mater Bar Turner

Ahonen Lumber Company, Ironwood, Michigan, softwood and hardwood Mater "Easy Shift" Edger

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Undergraduate Grants Awarded by NSF

Undergraduates will work alongside scientists of more than 250 colleges and universities beginning next summer as a result of National Science Foundation grants announced recently by Dr. Alan T. Waterman, Director of the National Science Foundation. The students will have the opportunity to engage in scientific research either as an individual working under the direct supervision of an established scientist, or directly with the scientist as a member of a research team.

The Foundation made available $3.2 million in 357 grants through its Undergraduate Research Participation program to help build the interest of superior students in research, to widen their understanding of scientific method, and to improve their ability to employ scientific investigative procedures. The program is now in its third year.

The grants, together with 165 awards made last year, will enable research participation by a total of 2,400 undergraduates during the summer of 1961 and about 1,900 during the 1961 academic year. A number of the grants are for two years, permitting extension through the 1962–3 academic year.

The newly-announced grants will allow for about 37 percent of the participants to work in chemistry, 26 percent in the biological sciences, 13 percent in engineering, and 12 percent in physics, with the remainder in astronomy, geology, mathematics, psychology, and the quantitative social sciences.

Fellowship, Scholarships Offered by St. Regis

St. Regis Paper Company offers one graduate Fellowship and five undergraduate Scholarships in forestry for the academic year 1961–62.

The graduate Fellowship, with yearly stipend of $1,000, is open to qualified graduates from recognized Forest Schools in the United States and Canada. It is not limited to present Seniors but is open to anyone qualified for matriculation for advanced forestry degrees whether at the Master or Doctorate level. The recipient may choose the institution for advanced study.

The five undergraduate Scholarships are for next year's Juniors in the following Forest Schools: Auburn University, University of Florida, University of Georgia, Universities of Maine, Massachusetts, New Hampshire, or The College of Forestry, State University of New York, and Universities of Idaho, Montana, Washington, or Oregon State College. These Scholarships each carry $800 per year for 2 years, with opportunity to work for the Company during the intervening summer. Senior year stipend depends on satisfactory record in field and in school work.

Applications for the Graduate Fellowship close March 1; for the Undergraduate Scholarships groups 1, 2, 3 and 4 above, September 1; and Scholarships group 5, April 15, 1961. A supply of applications is on file in the office of your school.

Extension Forestry Conference Reported

The latest information on the management, utilization and marketing of California's 6 billion board feet of hardwood timber will be presented at an Extension Forestry conference on the Berkeley campus of the University of California March 23 and 24.

Leading hardwood experts of the U. S. Forest Service, California State Division of Forestry, University of California, and California wood industry will address the meeting, announced Dr. Fred E. Dickinson, director of the U. C. Forest Products Laboratory. The conference is being sponsored by the University's School of Forestry, Forest Products Laboratory, and Agricultural Extension Service.

The opening day's program will feature discussions of California hardwood resources, the suitability of hardwoods for products as based on their physical and chemical properties, the present state of hardwood utilization, and the growing, harvesting and marketing of hardwood timber. On the second day, sessions will be devoted to the manufacturing and merchandizing of hardwood lumber, veneer, and charcoal. A tour of the Forest Products Laboratory will climax the conference.

Further information on the conference can be obtained by writing Ed E. Gilden, Extension forester, 23 Mulford Hall, University of California, Berkeley 4, California.

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NOXTANE
Controls ugly blue-black sap stains and mold. Keeps lumber bright and clear . . . stops costly degrading. Contains no arsenic or mercury—non-irritating and dustless—resists leaching from rain.

PRESSTREAT
Combination of PENTA **plus** water repellents for pressure treatment of lumber. Provides super above-and-below-ground protection against termites, other wood-boring insects, decay and fungus.

WOODTREAT A
A 10% Penta emulsion paste. Gives maximum protection to standing poles, piling, cutoffs, structural timbers. Applied by hand scoop, brush, paddle or mechanical spray. Clean to handle . . . not highly toxic.

TECHNICAL COUNSEL
Experienced specialists **plus** the most modern and complete laboratory facilities, are available for counsel and help on any wood preservation problem.

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Eliminates Culled Panels with
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At Bernhardt, as well as at many other laminating plants, Reichhold's PLYAMINE resins have proved themselves superior for high-strength, rigid bonding applications.

The forest and furniture industries have learned to depend on Reichhold for *fast delivery* of a full line of urea-formaldehyde, phenol-formaldehyde, polyvinyl acetate and resorcinol adhesives and protein glues.

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Ortho-Phenylphenol • Sodium Sulfite • Pentaerythritol • Pentachlorophenol • Sodium Pentachlorophenate • Sulfuric Acid • Methanol

CROSS SECTION

. . . Voice of Membership

Requests to Editor

. . . saw-guide gage . . .
Appleton Machine Co.
Mater Division, Corvallis, Oregon

. . . fire ratings on glulam . . .
New Zealand Timber Development, Inc.

. . . circular saws . . .
Sandvik Steel, Inc.
Fair Lawn, N. J.

. . molding wood particles . . .
Alton Box Board Co.
Alton, Ill.

. . . charcoal processes . . .
Coconut Industry Board
Kingston, Jamaica

. . . end- and edge-gluing . . .
Plywood Ponderosa de Mexico
Chihuahua, Mexico

. . . particle board . . .
American Store Equipment & Construction Co.
Muskegon, Mich.

. . . industry-education . . .
National Lumber Manufacturers Association
Washington, D. C.

Praises December Issue

Editor: The paper on stress values for West Coast white woods by E. M. Williston in your December issue deserves the attention of every western lumberman for it describes a problem of such significant portent that it literally threatens to explode upon the forest industry. The commercial importance of species which have in the past been relegated to the role of non-structural materials becomes greater year by year. The reported pattern of physical properties is also repeated for several other species which are not described in this very well presented case.

It is my habit to underscore particularly well made points in the articles I read. Practically every paragraph of this article bears the mark of my pencil.

In many other ways the December issue deserves comment. No one who reads the News-Digest Section can stand by and accuse our industry of lethargy, complacency, or short-sightedness. Valuable, useful effort and an attitude of mutual interest by F.P.R.S. members in our common problems is evident throughout this feature. President Berry's message on an issue of extreme member concern is well-timed. Its solution is sought with some impatience.

Dr. Fleischer's report on the "House & Home" Round-Table concisely draws together the collective impressions of well informed individuals whose attitude toward our products for use in house construction mean perhaps more than any single factor affecting the future of this market. This type of report is of immense value to the membership.

Charlie Lockard's article stimulates serious attention and directs us to a difficult problem that deserves all the attention for which he calls. Perhaps we have been too willing to accept the product of the headsaw as a starting point for new product development.

It is worth noting that whether my interest has centered around furniture manufacturing with hardwoods or wood building materials with softwoods, during the 10 years I have been a Journal reader, no issue has been lightly scanned.

The December Journal was outstanding and one which the membership can point to with pride.

ROBERT J. HOYLE, JR.
Assistant Director of Research
Potlatch Forests, Inc.
Lewiston, Idaho

Stress Values

Editor: I was glad to see the lead article "New Stress Values for the Coast White Woods" in the December Journal. This paper represents a distinctly worthwhile contribution to our knowledge of the properties of a group of species that have assumed increasing economic significance.

F. F. WANGAARD
Professtor of Lumbering
Yale School of Forestry
New Haven, Connecticut

Publication Honors Cloquet Center

A half century of forest research, education and demonstration is summarized in a recent publication by the University of Minnesota School of Forestry. The publication gives the history, achievements and benefits to the state of the University's world-famous 3,710-acre Forest Research Center at Cloquet, which began operations in 1910.

In that year, the first headquarters building, a log structure, was built. It is still in use, as the forestry foreman's residence. Facilities have now grown to 35 buildings including a sawmill, planing mill, wood treating plant and educational buildings to accommodate 72 students and the staff.

Research work at the center began in 1911 and has been constantly increasing and expanding to fit the demands of the ever-changing field of forestry. These research projects include: seedling production methods, weight method of purchasing pulpwood, wood treating plant development, continuous forest inventory, jack pine source of seed, service tests on treated and untreated posts, and development of wildlife management techniques.

Copies of the publication issued to observe the Cloquet station's first 50 years of service may be obtained from the Cloquet Forest Research Center, Cloquet, Minn., or from the Bulletin Room, Institute of Agriculture, University of Minnesota, St. Paul 1. Its title is "Cloquet Forest Research Center."

FPRS SECTION MEMBERSHIP GOALS

Wanted: 300 New Members by June 1, 1961

Section	New V. & A. Members Section Goal	Percent of Goal Attained	Membership Chairman
Midwest	30	43	R. C. Newstedt
Ohio Valley	10	35	H. E. Cook
Great Lakes	20	50	N. C. Franz
Upper Mississippi Valley	10	0	L. A. Ropella
Mid-South	25	64	H. L. Russell
Northeast	50	34	R. F. West
Eastern Canadian	20	80	Alfred Glennie
Carolinas-Chesapeake	25	48	Sam Freeman
Southeastern	10	50	P. J. Bois
Pacific Northwest	50	26	Tom McKenna
Inland Empire	10	40	R. L. McNett
Northern California	20	55	Victor Roth
Rocky Mountain	10	30	R. S. Bader
Pacific Southwest	10	60	W. E. Ripley, Jr.

As of January 1—halfway mark in the membership drive—Section Membership Chairmen are generally meeting their quota. Alfred Glennie, Eastern Canadian Section, leads with 80 percent of his goal attained. Harry Russell, Mid-South Section, is in second place with 64 percent. Who will be first to go over the top?

Help your membership chairman meet his quota!

See Reader Service Form, page 22-A.

Lumber Grading Course Offered at Penn State

The Pennsylvania State University is offering the annual Hardwood Lumber Grading short course from March 27 to 31. The course consists of classroom lectures and demonstrations and student participation in lumber grading and measuring. Included in instruction is considerations of miscut, thickness, lengths, measurement, and tally of lumber; interpretation of hardwood rules; clear face and sound cuttings; standard defects; methods of applying the rules and exceptions to standard grades. Emphasis will be placed upon local Pennsylvania hardwoods. Actual grading and measurement practices will be done at nearby mills.

The registration fee for the course is $25 for Pennsylvanians, and $30 for non-Pennsylvanians. Application blanks and the daily program can be secured from the Director of Short Courses, College of Agriculture, The Pennsylvania State University, University Park, Pennsylvania.

Insect Enemies Photographed By U. of C. Scientist

A University of California scientist is developing an x-ray method of probing the private lives of insect enemies of the state's valuable forests. Using an ordinary x-ray machine, Ronald W. Stark, assistant professor of entomology on the Berkeley campus, is photographing insects hidden below the surface of sections of tree bark. He reports that the pictures provide an easy, fast, and efficient means of studying the population fluctuations of insects and their life cycles without harming them.

In the past, Stark pointed out, forest entomologists spent many hours patiently chiseling away layers of bark to expose the insects within the sections and usually destroyed them in the process. He is conducting investigations of the western pine bark beetle, No. 1 menace to California's coniferous forests, tip mining insects, cone, seed and wood-boring insects with the aid of the x-ray technique. The initial results of these studies lead Stark to believe that the method will become an important tool in the field of forest entomology.

"X-ray photographs would assist scientists in predicting insect populations and estimating damage to forests," he said. "The pictures also would help them chart the life histories of insects and learn how parasites and predators operate on them."

Aided by Dr. C. Willet Asling, professor of anatomy at Berkeley, Stark hopes to devise a portable x-ray machine that could be employed to carry out entomological research on living trees in the forests. He suggested that such an instrument might be capable of performing other services for groups concerned with detecting the presence of insects in wood.

"Federal and state inspectors at ports of entry could possible use it to discover destructive insects in imported timber," Stark said. "A light, easily-transported machine also might be employed to discern the extent of internal damage to timber products caused by insects where there is no external evidence of harm."

U. of C. Lab Reviews Research Progress

Research achievements of the University of California's Forest Products Laboratory was reviewed by its Technical Advisory Council during the fall meeting at the Richmond Field Station on Friday, December 2. The Council heard reports on studies of the use of bark extractives as an adhesive in particle board, nitric acid pulping, and redwood stain control. Wood research being conducted in the University's College of Engineering also was discussed by Dr. Howard Eberhart, chairman of the Department of Civil Engineering.

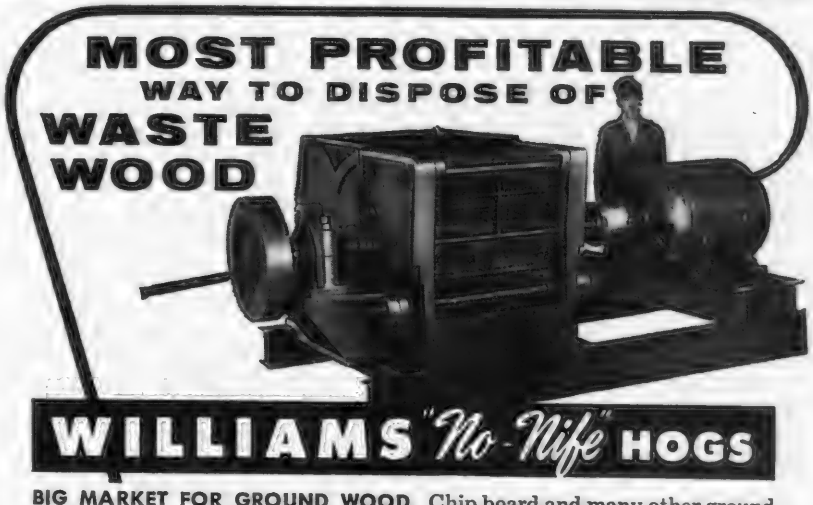
Dr. Joseph E. Marian, wood technologist in the Forest Products Laboratory, outlined developments in the field in India where he recently served as advisor to the National Council of Applied Economic Research. The financial status of the Forest Products Laboratory and its relations with the lumber and wood products industries were reviewed by Director Fred E. Dickinson.

1961 "Where To Buy" Published by WCLA

The 1961 edition of the "Where To Buy" directory, West Coast Lumbermen's Association's complete buyer's guide, is now available to retailers, wholesalers and specifiers throughout the nation.

This year, the "Where To Buy" is designed to perform double-duty. In addition to its primary function as a WCLA directory, listing mill addresses, personnel, species and manufactured items, the book features full-color front and back covers with detailed information on utility grade West Coast lumber.

The 52-page booklet lists approximately 250 sawmills in the Douglas Fir Region, with their capacity, facilities, species produced and each mill's major and specialty items. Each mill's manufactured products are included in a column breakdown of 55 items, including such things as window and door stock, bevel siding, mouldings, shop lumber, sash and frames, log cabin siding and pickets. **Circle Item 1**



BIG MARKET FOR GROUND WOOD. Chip board and many other ground wood products offer a tremendous market for waste wood—but manufacturers of these products demand uniformity in quality and size—requirements that Williams hogs are fulfilling in dozens of plants. Whether the wood scrap you sell is in chips, sawdust or flour, a Williams will produce more, faster, with less labor, power and upkeep.

BIG INCREASE IN HEAT VALUE. Wood waste for fuel yields more heat when hogged in a Williams for uniform, complete combustion. Unhogged wood restricts air flow, smothers the fire, burns unevenly, creates excessive smoke. Williams equipment also reduces handling costs as much as 75%! When hogged, one man can handle as much as three men can handle in long, cumbersome pieces.

WILLIAMS AUTOMATIC INSTALLATIONS EARN PHENOMENAL PROFITS when used for hogging and conveying wood waste to boiler or stoker—or for grinding, separating and packaging ground and sized wood.

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CRUSHERS GRINDERS SHREDDERS
OLDEST AND LARGEST MANUFACTURER OF HAMMER MILLS IN THE WORLD

DELWOOD MOLDING PROCESS: Industrial chipper converts aspen logs to chips, which are then conveyed through shaker-sorter. Patented "wet and dry" mixer blends dried wood chips with chopped fiberglass and polyester resin. Products, such as sofa wings, are molded in specially designed presses.

New Wood Chip Material For Contoured Shapes

A new molded material, consisting of aspen wood chips, chopped fiberglas, and polyester resin, has been announced by the Gisholt Machine Co., Madison, Wis.

Called "Delwood," after developer D. E. Lawrence, the new material offers fracture strength approximating that of hard maple. When molded at pressures between 300 and 500 psi, Lawrence, who is Director of Research for Gisholt's Masterglas Plastics Division, reports that the specific gravity of the new product approaches 1.0.

Tests in cooperation with the U. S. Forest Products Laboratory indicate "Delwood" has high moisture resistance and good dimensional stability. It can be drilled and doweled and has screw-holding power comparable to that of hard maple.

The new process should find applications in many fields, according to Lawrence, because it allows intricate shapes to be used at minimum cost and assures consistent quality with dimensional accuracy.

Wood chips produced in an industrial chipper are conveyed through a shaker-sorter, then they are blended in the desired proportions with chopped fiberglass and polyester resin.

The materials are blended in specially designed "dry" and "wet" mixers that permit accurate control of moisture content, resin content, and specific gravity.

The molded parts are shaped with inexpensive cast iron and kellered boiler plate dies and molded at pressures ranging from 300 to 500 pounds per square inch.

Small parts are molded in 65-ton presses designed so that the cavity part of the mold slides out as the press opens. This provides easy access to the die and assures maximum safety for the operator. The speed of the press operation permits one man to handle up to four presses at a time, depending on the part and the number of pieces produced in each press.

The unique die concept, the "wet" and "dry" mixers, and the presses were designed and built by Gisholt. Patents have been issued or are in process for the entire program.

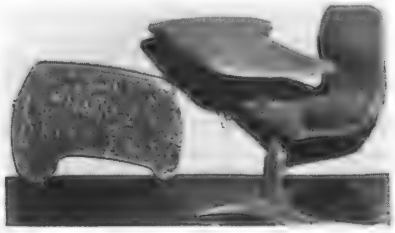
Gisholt's pilot operation is now capable of producing about 4,000 pounds of molded products per day. Recent emphasis has been on such products as wing structures for upholstered furniture, curved seats, and understructures for school desks.

When flakes rather than chips are molded under higher pressures, the process lends itself to display letters for outdoor signs, shoe lasts, and picture frames.

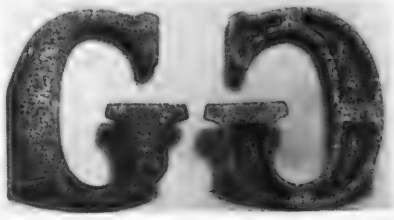
A current project is the development of a molded bowling pin core that Lawrence believes will have the properties of hard maple.

Circle Item 2

BOTTOM HALF OF DIE slides out for safe, fast loading and unloading. Depending on parts being molded, one operator can handle up to four presses at a time.



MOLDED TOP assures strength and rigidity for fiberglass school desk.



DISPLAY LETTERS for outdoor signs or indoor exhibits.

Wood Pole Conference To Be Held at N. C. State

The Wood Products Department of the North Carolina School of Forestry is sponsor of "The South Atlantic Wood Pole Conference" at Raleigh, N. C. on April 5th and 6th. The conference will be held in the Student Union on the campus of the North Carolina State College.

A comprehensive program of basic technology and current information on the production, deterioration, preservative treatment, purchasing, inspection and maintenance of wood utility poles will be presented. Technical papers which will also be pre-printed and bound will be presented by industrial educational and governmental specialists and researchers.

The conference is open to all interested persons. Persons wishing to attend the South Atlantic Wood Pole Conference may obtain copies of the conference program and advance registration by writing to the Wood Products Extension Section, 226 Kilgore Hall, North Carolina State College, Raleigh, N. C.

Stumpage, Log Marketing Studied in California

Improved timber marketing practices on small forest properties in California's Central Sierra Nevada region would boost income, stimulate better management, and assure local lumber industries of adequate supplies. This is the major conclusion of a report on a study of the marketing of stumpage and logs from privately-owned forest properties of 5,000 acres or less in El Dorado, Placer, and Nevadea counties.

The report describes current timber marketing practices in the region, evaluates their effectiveness, and suggests means of improving them. A University of California research team composed of forest economists Dennis Teeguarden, Paul Casamajor, and John Zivnuska conducted the study.

The report was published recently in a California Agricultural Experiment Station Bulletin titled, "Timber Marketing Practices and Land Ownership in the Central Sierra Nevada Region." Copies of the bulletin can be obtained from U. C. Agricultural Extension Service county offices throughout the state.

See Reader Service Form, page 22-A.

FURAFIL® 100-S

The PROVEN phenolic resin glue extender

Furafil 100-S is accepted because:

1 It has complemented successful resin glues for Douglas fir, poplar, balsam and a variety of other western plywood species.

2 It has performed consistently in areas ranging from the Northern Alberta subarctic to the warm Central California valleys.

3 Glues extended with Furafil 100-S have met every variation of mill conditions.

4 It has been in continuous use for over 8 years.

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Ask your resin supplier for his recommended formulation.

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Room 6153B, 815 Superior Ave., Cleveland 14, Ohio
Room 543B, 120 Wall Street, New York 5, New York
Room 443B, 49 S.E. Clay Street, Portland 14, Oregon

 See Reader Service Form, page 22-A.

New Kiln Installation At Moyie Springs, Idaho

A modern dry kiln installation has just been completed at Moyie River Lumber Company, Moyie Springs, Idaho. The 104-foot long single-track kiln, built by Standard Dry Kiln Company, has a holding capacity of 45,000 feet of 4/4 lumber. Part of a modernization and expansion program begun in June 1960, the new kiln will greatly increase Moyie River's present drying facilities.

Fourteen high-volume direct-drive internal fans are incorporated in the kiln's ventilation system. These are operated automatically by means of a fan reversal control system. Other control features include a temperature and humidity recorder controller which maintains fully automatic control in the drying chamber, plus a prewired electrical control panel. The latter is an exclusive feature of Standard dry kilns. A high radiation heating system makes for fast uniform drying.

Circle Item 3

U.S. Plywood Announces Recent Purchases

More than 100 million board feet of standing timber has been acquired by United States Plywood Corporation from Stebco, Inc., an Oregon corporation.

Gene C. Brewer, U. S. Plywood president, reported that much of the timber would serve as a raw material source for the company's Willamina, Oregon, plywood plant, one of five operated by the company in that state.

U. S. Plywood has also purchased, for cash, a one-half interest in Bohemia Lumber Company, Inc., of Culp Creek, Oregon.

The corporation is presently purchasing under sales contract Bohemia's fir plywood production, which amounts to approximately 60 million square feet annually. In addition to its plywood plant, Bohemia operates two sawmills with an annual capacity of 60 million board feet. The company also owns more than 300 million board feet of old growth timber in Oregon. It will continue under present management.

To Determine Moisture Content Abrax Hygrometer

The Abrax Instrument Corporation, New York, announces the production of its new Abbeon Model No. R560 Container Type Hygrometer. This instrument is used for obtaining the relative humidity of samples of grainy or powdered materials such as wood flour, sawdust, tobacco, grain, flour, etc.

The instrument consists of two parts. An especially calibrated Abbeon Hygrometer which fits into the top of an oxidized aluminum container. The sample to be tested is placed in the aluminum container and the Hygrometer is inserted into the top of the container and left there for approximately 20 minutes at the end of which time the Hygrometer will indicate the relative humidity of the sample.

Once the relative humidity of the sample is known it is then possible to determine the percentage of absolute moisture of the sample by consulting a table of humidity equilibrium. Tables are included with each instrument giving the humidity equilibriums for a number of products. These tables are calibrated in 2 percent increments from zero to 100 percent.

Circle Item 4

Plenum Floor Trusses For On-Grade Use

A new system of metal W-trusses and wood joists for home building is said to create an above-slab plenum with concrete slab construction that gives basement comfort and numerous construction advantages.

The new system, designed by G. J. Stout, Building Industry Research, Pennsylvania State University, was recently demonstrated at the University of Illinois.

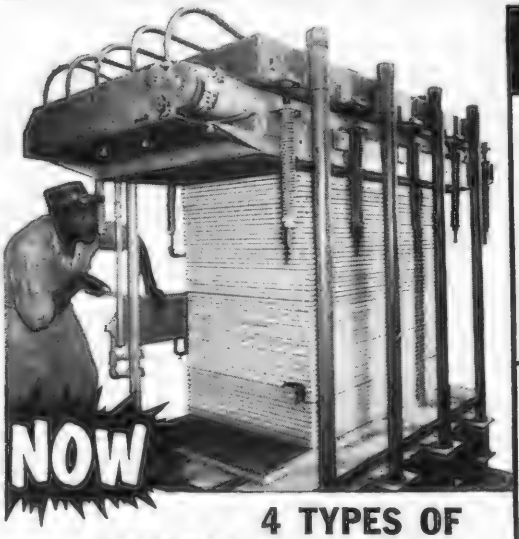
The W-truss floor supports (patent pending) are stamped out of light-weight metal in such a form that they have unusual strength, and they are easily attached to the joists or floor stringers.

Approximately 400 trusses are needed for a house with 1000 square feet of floor space, with the joists spaced 16 inches on center. This system would support a total load on the floor area of more than 200 tons.

Any finish flooring material suitable for a conventional house with wood joists can be used with the plenum floor, including regular hardwood or panelized, prefinished hardwood plywood, according to Stout.

The trusses are a product of Templin-Stout, Inc. Literature and technical data are available.

Circle Item 5



4 TYPES OF LAMINATING PRESSES

BLACK BROTHERS now offer four answers to your laminating problems—in four types of presses—properly engineered for the laminating process which you prefer. Get full details by writing for specific product bulletins!

AIR HOSE LAMINATING PRESS—BULLETIN 11-D. A high production press for moderate pressure bonding with vinyl and other adhesives. Platen size 30" x 30" to 62" x 120".

ROTARY PRESS — BULLETIN 11-C. For laminating dissimilar plies when bonding with rubber base instant contact bond adhesives. Roll widths to 134"; pressing speeds 10 to 60 FPM; max. pressure 12,000 lbs.

MOTORIZED LAMINATING PRESS—BULLETIN 11-E. Especially popular for laminating composition board, flush doors and plastic laminates. Use with or without retaining clamps. Capacites 36" x 36" to 58" x 200".

HYDRAULIC LAMINATING PRESS—BULLETIN 11-P. Preferred for laboratory, expermental and light production work. Standard sizes from 1 to 9 sq. ft.; pressures to 100 tons.

THE BLACK BROTHERS COMPANY, INC.
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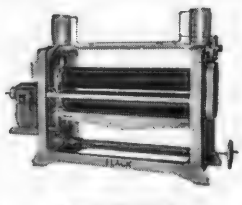
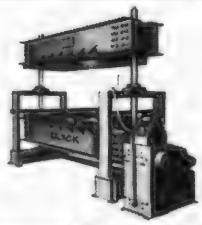
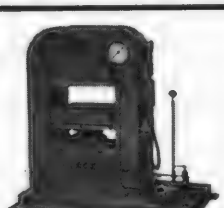
BLACK BROTHERS COLD PRESSES

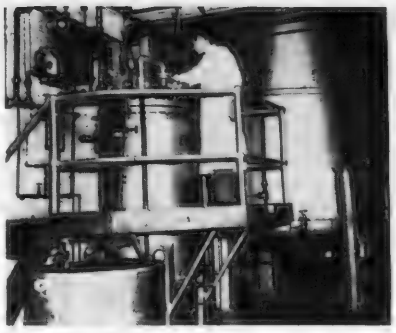
AIR HOSE LAMINATING PRESS


ROTARY PRESS


MOTORIZED LAMINATING PRESS


HYDRAULIC LAMINATING PRESS

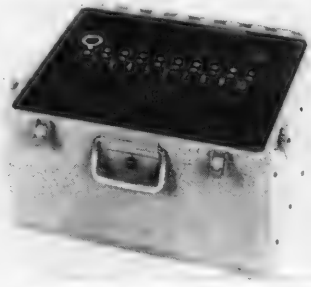
See Reader Service Form, page 22-A.



Miles Chemical Reports New Cellulase Enzyme

Miles Chemical Company, a division of Miles Laboratories, Inc., Elkhart, Ind., has developed a new cellulase enzyme—Takamine Cellulose 4000— which possesses excellent stability and activity under a wide range of conditions. It hydrolyzes and thus depolymerizes cellulosic materials. It is commercially available with standardized 4000 cellulase units per gram. It is also available commercially up to levels having 3 times this standard potency. Quantities are unlimited.

The new enzyme is the result of an intensive 4-year research program by Miles Chemical's Takamine Laboratory, Clifton, N. J., a pioneer and developer of the widest assortment of enzymes in this industry Cellulase is a standardized enzyme preparation which attacks cellulose and other beta-glucosides. Heretofore, available cellulase enzymes have evidenced marked inability for concerted activity under varying conditions. The new Miles enzyme meets these problems head-on. It digests quickly and efficiently paper, cotton, wood, soybean hulls, barley gums, grape pomace, carboxymethyl cellulose and other cellulosic materials. Above, an operator is setting seed tanks for subsequent innoculation of larger growing fermenters. **Circle Item 6**



Trimstat Control System

The "Trimstat" Memory System, a new control system designed for trim saw and similar applications, has been announced by Republic Electric & Development Co. of Seattle.

Standard features of the new Trimstat system include automatic random end trim from the customer's limit switches, and hold-down of saw on successive cuts. Panel lights indicate all relay operations, and plug-in relay packages facilitate ready replacement and trouble-shooting. Spare relays and relay test plug are included. Isolating transformer and fuse are also provided. **Circle Item 7**

'61 WPA Directory Released

More than 450 mills are listed in the newly published 1961 membership directory of the Western Pine Association. The 28-page book is also the lumber trade's buying guide to sources for Western Pine Region lumber products, and includes listings on each mill for species, products, capacities, plant and sales office locations, as well as seasoning, branding and unitizing services. Thus it also bears the title "WPA Sources of Supply."

The Association's member mills, representing approximately 400 separate companies, are located in the big 12-state Western Pine Region. The total industry annually produces about one-third of the nation's softwood **Circle Item 8**

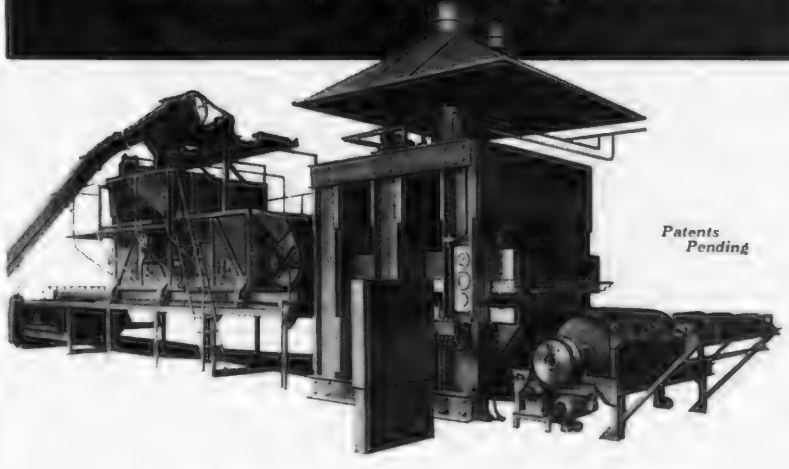
Laminated Oak Flooring For Trucks and Trailers

E. L. Bruce Co., world's largest maker of hardwood floors for homes, is now marketing a heavy-duty, laminated oak flooring made especially for use in transport vehicles. To be known as Bruce Dura-Wood Truck and Trailer Flooring, the new product is shipped pre-cut in full trailer or truck-length boards, and in withs to 12 inches.

Substantial savings result in installation, since cutting, matching and joining of random-length boards over stringers in the vehicles is eliminated. Produced by electronically gluing random-length oak strips to the desired length and width, the flooring has an edge-grain surface for extra durability.

Circle Item 9

Flakes into Flakeboard with the *Bison System*



Producing the world's finest Flakeboard

Semi-Automatic Operation

Low Installation, Production and Maintenance Cost

Single or Multi-Press Installations

Before you invest–*investigate!*

Get the complete story on the Bison System.
Films and literature available. Call, wire or write:

SODERHAMN MACHINE MANUFACTURING COMPANY
Talladega, Alabama
West Coast: 9442 S.W. Barbur Blvd., Portland, Oregon

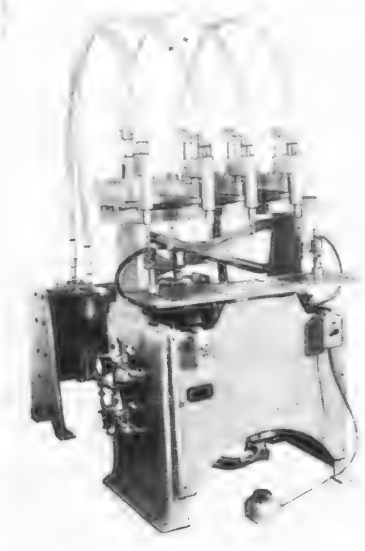
 See Reader Service Form, page 22-A.

Corvallis Center Studies Wood Residue Particles

Information important to development of new and improved uses for sawdust and shavings has been obtained by studies at the Oregon Forest Research Center in Corvallis. Distribution of size of particles from various types of saws and planers was determined in a survey of mills in the Willamette Valley.

Half the volume of a log remains as residue when it is cut into lumber, stated S. E. Corder, research engineer who directed the study. Uses exist for the 25 percent of residue that is sawdust and 15 percent that is planer shavings, but large quantities remain unused. Knowledge of size of particles may aid increased utilization of residues, Corder explained.

Similar distribution of size of particles was obtained with sawdust from band headsaws and band resaws. Circular headsaws produced sawdust of same distribution in size as sawdust made by circular edgers, Corder stated. Sawdust from band saws was smaller in size than was sawdust from circular saws. Gangsaws produced sawdust that had a distribution in size between that of band saws and that of circular saws. More small particles were found in planer shavings from kiln-dried lumber than were found in shavings from undried lumber, Corder said. Information on size of particles from mills in the Willamette Valley is available upon request. **Circle Item 10**



Vertical Boring Machine

Extreme flexibility and quick set-ups are two important features of the new Indiana Type 4S vertical boring machine. Offered in two sizes—3 feet and 6 feet—this vertical borer can bore any number of holes from 1 to 24 at a pass, on centers from 1 inch minimum up to 72 inches maximum.

The machine uses a flexible shaft as the means of power transmission. The cable around the core of the flexible shaft offers a highly desirable safety feature. No high speed rotating parts are exposed. Every adjustment necessary for a universal machine is included with the highest adjustment about eye level. **Circle Item 11**

Pneumatic Conveying Systems

The new Crown Zellerbach Corporation small log sawmill at Columbia City, Ore., is leading the way in increased utilization of wood products. To realize the greatest return from two products, pulp chips and sawdust, the new mill employs two high pressure pneumatic conveying systems designed and built by Archer Blower & Pipe Co., Inc., of Portland, Ore. The twin-systems convey screened pulp chips 250 feet and screened sawdust 300 feet separately to a car loader that loads parallel cars simultaneously for transport to the company's pulp plant.

Each Archer System consists of a rotary feeder and a positive blower designed to convey chips and sawdust a predetermined distance at a predetermined tons-per-hour capacity. The feeder acts as a metering device injecting screened material into the discharge pipeline without allowing air to escape. The pump-type rotary blower is designed for 6 pounds psi maximum pressure at a predetermined ratio to the system, and is a two-impeller positive displacement blower.

The conveying system is rated at 30 tons per hour capacity with material being conveyed several hundred feet through a high-pressure discharge pipeline. The sawdust cars are on a track adjacent to the chip cars, and are loaded from a dual-outlet. This arrangement permits immediate transfer of fill operations to an adjacent empty car enabling the system to operate continuously. **Circle Item 12**

Helyx Drive Screws

Helyx Drive Screws, made by Hillwood Manufacturing Company, Cleveland, Ohio, cut pallet and construction costs—through unmatched holding power. The Helyx Drive Screw is made from heat-treated and tempered steel. The screws are unique—made from square wire, twisted to provide the thread. Absolute uniformity of root and crest diameters is assured—holding power of the nail never varies.

Though driven with a hammer or by machine, they turn and hold like a screw. Holding power is 220 percent of a common nail—125 percent of a wood screw. In addition to standard points, Helyx Drive Screws are available with chisel nonsplit points. This eliminates splitting hardwood boards, even when driven within one-fourth inch of the edge or end.

Circle Item 13

Portable Brush Chipper

The Gruendler Crusher & Pulverizer Company Bulletin #C-3 describes a portable brush chipper. The bulletin illustrates the adjustable chipper throat and the rotor with adjustable knives, gives data and information on how to use the brush chips as a soil conditioner or mulch, and includes specifications on the 10 x 12 and 10 x 16 chippers and trailer units. **Circle Item 14**

Harnischfeger Cranes

A crawler crane capable of reaching 30 stories high with its 310 feet of boom and jib pours concrete during construction of a penthouse apartment building in New York City. The crane, P&H Model 1015, is one of 40 power crane and shovel models offered in 1961 to the construction and mining industries by Harnischfeger Corp. of Milwaukee.

Jack F. Catalane, general sales manager of the firm's construction and mining division, said that the line, called the "Fabulous 40," covers the widest range of lifting and digging capacities ever offered by a single manufacturer.

Circle Item 15

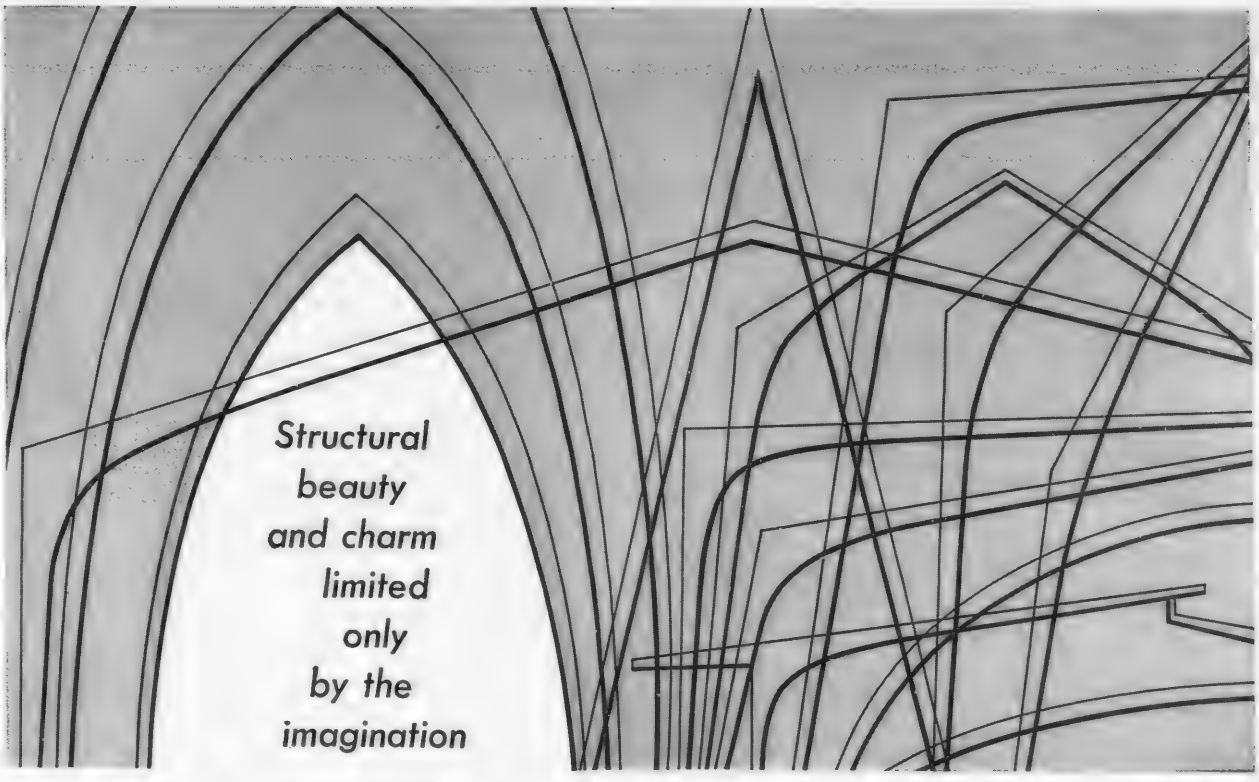
Lumber Dried Faster With Forced Air

Cost of shipping lumber can be reduced by drying it with forced circulation of air, according to C. J. Kozlik, in charge of studies on wood seasoning at the Oregon Forest Research Center, Corvallis, Ore. Reduction in shipping charges more than offset cost of forced-air drying in tests conducted at Lebanon in the Willamette Valley and at Medford in southern Oregon.

For the tests, lumber was stacked 2 rows wide and 3 tiers high along both sides of an 8-foot alley. Portable aluminum roofs protected the lumber Five- and 6-foot fans powered by electric motors were placed at each end of the alley. Fans operated automatically and ceased operation when relative humidity exceeded 90 per cent, Kozlik said.

In the Willamette Valley, forced-air drying was successful throughout the year. Time required for drying lumber increased during the winter, but still remained economically adequate. High relative humidities and low temperatures made forced-air drying at Medford appear unsatisfactory during winter months, stated Kozlik.

See Reader Service Form, page 22-A.



PENACOLITE® Adhesive laminated timbers permit extensive freedom of design . . . economically

Wooden arches, beams and trusses laminated with waterproof PENACOLITE resorcinol adhesives – for bonds stronger than the wood itself—offer the designer full freedom of expression. These glues allow wooden members to be easily shaped to any desired form in either traditional or contemporary design with many combinations and variations of the basic types . . . without losing inherent structural strength.

Economy of Laminated Wood Construction

Laminated wood is one of the most economical types of construction. It arrives at the job site already fabricated and cut to size for fast erection—resulting in reduced construction costs. In addition, laminated timbers with their natural color and beauty eliminate the need for costly concealing finishes.

PENACOLITE adhesives will retain their strength even under the most exacting temperatures, ranging from —40°C. to temperatures that char the wood—earning for laminated members favorable fire insurance rates.

Room Temperature Curing with PENACOLITE Adhesives

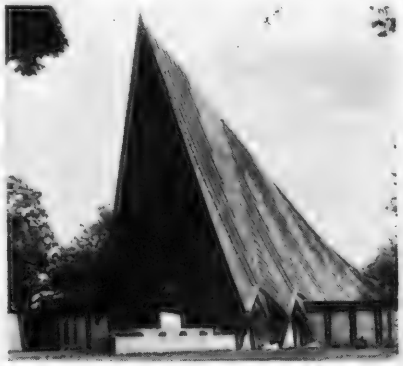
PENACOLITE adhesives are thermo-setting resins that cure easily at room temperature (70°F.). The curing process is irreversible—glues cannot be softened by further heating.

Write for the PENACOLITE Adhesives brochure, C-6-149, Koppers Company, Inc., Chemicals and Dyestuffs Division, Pittsburgh 19, Pennsylvania.

KOPPERS®

Photo, Unit Structures, Inc.

Carousel Theater, University of Tennessee—Penacolite adhesives bond these exposed timbers. Building octagon shaped. Arches—"V" type. Span—60'.

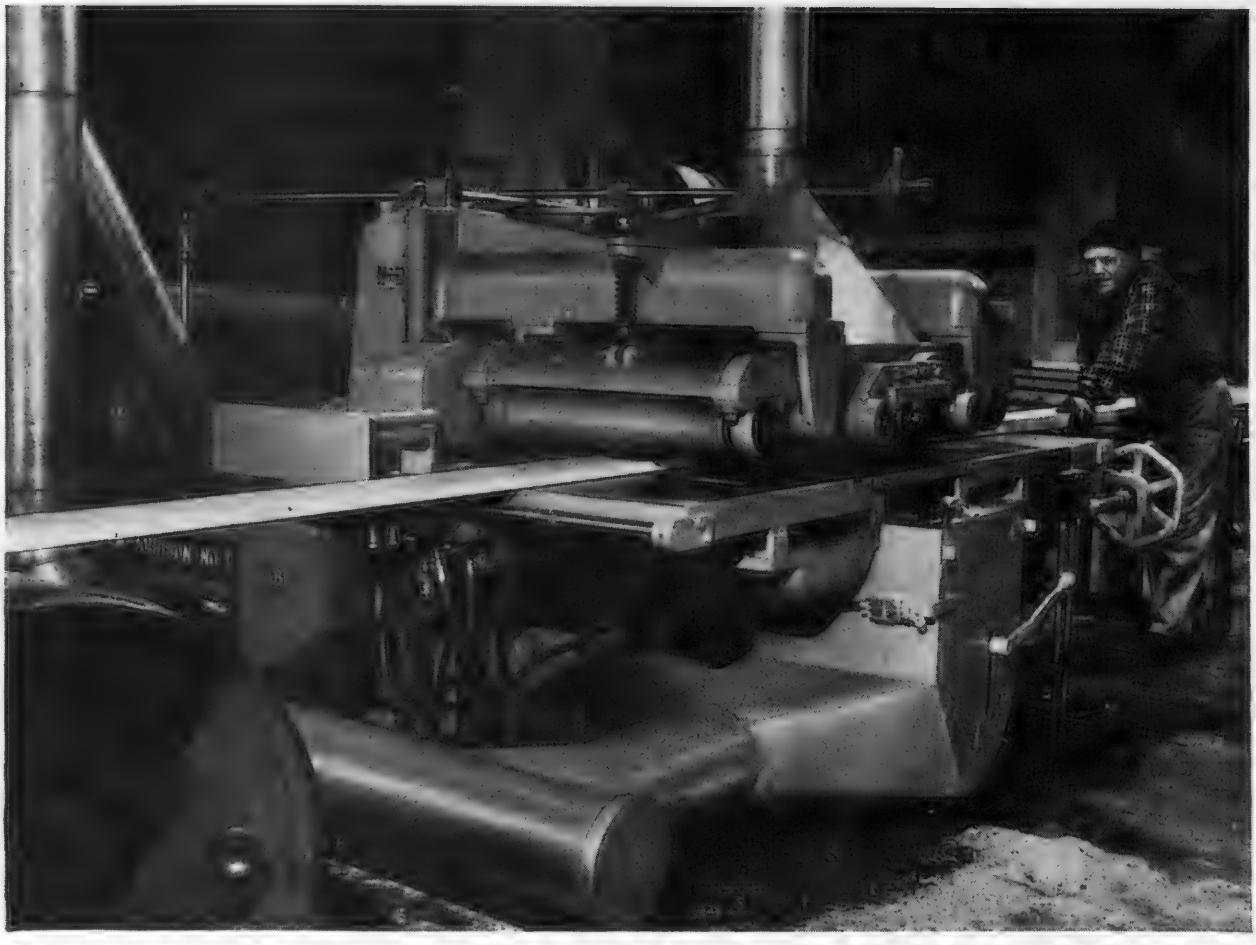


Photo, Unit Structures, Inc.

Church in Conover, N.C.– Bonding adhesives—Penacolite. Arch span varies from 37'3" to 97'10". Roof pitch varies per foot from 34-27/32" at one end to 4-5/8" at the other.

Photo, Unit Structures, Inc.

Dierks Forest Company Office Building, Hot Springs, Arkansas—Penacolite adhesives were used in this modern office building in laminated timbers.



Mereen-Johnson **441-A SPLITTER**

Saves Money and Manpower at Potlatch Forests, Inc.

A new Mereen-Johnson 441-A Splitter has established impressive cost savings for Potlatch Forests, Inc., Coeur d'Alene, Idaho, because it has completely eliminated one re-planing process and the need of re-assorting for grade as done previously. P.F.I. has been able to reduce its force by four men as a result of the combined splitting and re-planing services the machine can perform.

Potlatch Forests, Inc., cuts logs from its own timber stand and ships them to the plant. Due to a 15 per cent average run of common grades, and an annual volume of 70-75,000,000 board feet, up-grading was necessary.

Utilizing the combination features of the M-J 441-A Splitter there is no necessity to operate a feeder, grader, planer and rip-saw.

With the 441-A Splitter the re-manufactured lumber can reach the final stage of production two days sooner than under the old method. The 441-A now eliminates those additional steps that were once a necessity.

The M-J 441-A Splitter permits Potlatch to up-grade by one or two grades. It eliminates a complete production step saving them money, manpower and time.

Write for information on the 441-A on your company letterhead.

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See Reader Service Form, page 22-A.

FPRS FOREST PRODUCTS JOURNAL VOL. XI, NO. 2 FEBRUARY, 1961

Progress in Logging—1960[1]

J. A. DOYLE
Chairman, FPRS Timber Production Division

NATIONALLY, in both the United States and Canada, the logging industry continues to operate in a healthy condition. The reasons for continued success in the face of increasing labor costs, locally depressed markets, and other disturbing influences of greater or lesser import, have been largely due to the adaptability of the industry to new methods and equipment. Also responsible, it is felt, is the realization of the growing importance of considerations of timber quality in logging. In this connection, it is interesting to note that the United States government has implemented a program of log and tree grading on a national basis, the results of which are just beginning to be felt. The broad aims of this program are to place the exploitation, utilization, and marketing of forest products on a national basis with the result of ultimate benefit to all.

Below are outlined some of the developments in the industry from different parts of the continent, as prepared by the committee.[1]

SKYLINE LOGGING with a radio-controlled Skagit carriage makes it possible to log previously inaccessible areas.

Eastern Canada

The past year was one of mixed trends in the lumber industry and these, of course, were reflected in logging activity. The softwood market was generally depressed due almost entirely to the low level of activity in the construction industry. This meant that some summer logging was curtailed substantially, while in other cases winter programs will be cut back to allow inventories to diminish. Hardwoods, on the other hand, were comparatively strong and logging was very active. Many of the Eastern Canadian hardwood logging operations are not fully mechanized and sales of mechanical skidders, loaders, and other equipment were at a record high.

Two logging field meetings—both sponsored by the Canadian Pulp and Paper Association—were held during the period. The first meeting took place on the Iroquois Falls limit of the Abitibi Pulp and Paper Co. Ltd.; the second, on the University of New Brunswick Forest at Fredericton, N.B. Many new pieces of equipment were demonstrated, as well as some interesting applications of existing machinery. One item of particular interest was the cable-yarding system employed by Abitibi specifically for their Iroquois Falls limit. The equipment was in full production and not installed merely for demonstration purposes. The Timberland yarders operated to a distance of 500 feet on either side of a winter strip road, bringing in 16-foot black spruce pulp logs to a cold deck. The principal reason behind this mechanization program is the muskeg terrain, which comprises a major portion of the limit, and is virtually impassable by horses or crawlers during the summer. Thus, former operations on the limit were confined to winter cuts.

Research in logging continued to be active. The Forest Products Laboratories of Canada continued their harvesting and conversion studies. In this respect, an interesting operation that combined the use of rubber-tired skidders, small crawler tractors, and rubber-tracked skidders, was studied. Work in log grading was also continued by the FPLC. Of special interest, was a study of a large, commercial, hardwood logging operation where two similar cutting areas were pre-selected and subsequently logged as follows: Area 1 was cut under normal operating procedures of the Company. Area 2 was logged under the supervision of FPLC staff who followed principles of log grading and sound bucking techniques. Preliminary results indicate the increase in both unit value and total volume to be substantial.

Another very interesting development—which, if found to be commercially expedient, will have a profound effect on logging procedures—is the water-filled pipeline for pulp chip transport. The results of this research, which was undertaken at the Pulp and Paper Research Institute of Canada, indicate the method is technically feasible. (See the August *Journal*)

Southeast

Since early summer, there has been a definite slump of the lumber and tie market in the Tennessee Valley and ad-

The Author: J. A. Doyle is head of the Wood Utilization Section, at the Ottawa Laboratory of the Forest Products Laboratories of Canada, Department of Forestry, Ottawa.

[1] Contributors to this report of the Timber Production Division include: W. W. Calvert, Forest Products Laboratory, Ottawa; Fred C. Simmons, Northeastern Forest Experiment Station, Upper Darby, Pa.; J. W. Lehman, Norris, Tenn.; W. J. O'Neil, Columbia, Mo.; George Stenzel, University of Washington, Seattle, Wash.; and J. A. Holekamp, American Pulpwood Association, Sylacauga, Ala.

NODWELL SKIDDER equipped with trolley skip. (Courtesy Woodlands Review, Pulp & Paper Magazine of Canada.)

NODWELL SKIDDER releasing load of 8-foot pulpwood logs. (Courtesy Woodlands Review, Pulp & Paper Magazine of Canada.)

joining areas, which has influenced logging operations throughout the region. One effect is that loggers are becoming more cost conscious, and there is a definite attempt to convert the tree in the most valuable products. This has resulted in a more intensive search for favorable markets and greater efforts to make products that will show maximum profits. The trend has shifted away from lumber and toward other products. Where lumber and ties probably accounted for more than 90 percent of the production in the past, they now appear to represent only 60 percent. Part of this trend can be explained by the market slump, but part of it is due to the kind of timber being harvested. Large amounts of high-quality saw logs are no longer available. Most of the stumpage now is in medium- and low-quality trees, and other markets besides lumber are being found in order to use these trees at a profit. Farther south, there has been much closer utilization of pine because of the increased use of debarking and chipping facilities to produce pulp chips.

There is a trend toward greater mechanization. For example, more loggers are using mechanical loaders, and the use of larger trucks is also becoming increasingly popular. Within the past 5 years, there has been a definite shift from two-man chain saws to one-man chain saw.

The use of rubber-tired wheel-tractors is increasing. However, there is still a considerable amount of logging done with the aid of animals, especially for the short skidding distances. For longer distances, tractors are used, and a few operators are skidding full length trees.

CABLE YARDER used by Abitibi Pulp & Paper Co. on Iroquois Falls limit operates 500 feet on either side of strip road. Muskeg terrain is virtually impassible by tractor or animals in summer. This composite photo shows yarder bringing 16-foot black spruce logs to cold deck. (Courtesy Woodlands Review, Pulp & Paper Magazine of Canada.)

In the steep terrain of the Southern Appalachians, a large part of the forest is in public ownership. In timber sales from public lands, restrictions are usually made to protect the watershed values of the areas. Initially, most of the loggers resented these restrictions. However, over the past several years it has become apparent that the methods that provide watershed protection are also the most economical. The result is that most loggers are now aware of the advantages of protective watershed logging, and many are even applying it to privately owned land.

More logging research is needed in the region. Probably the most immediate need is information on cost minimization so that an operator can decide on the combination of methods and equipment that will do the job most economically.

Pulpwood harvesting in the Tennessee Valley area is slowly becoming more and more mechanized. Practically all felling and bucking is now done with one-man power saws. Mechanical loading equipment is also beginning to appear in the valley. Most common is the 4-foot boom (dubbed the "Big Stick") and winch with about 250 feet of steel cable all mounted on a pulpwood truck and operated by a power take-off from the truck engine. Skidding is still being done mainly with single animals, but the use of tractors is increasing. Some producers are turning to pallet operations as a means of reducing costs and keeping haul trucks on the road.

The Southern Pulpwood Industry[2]

Progress within the southern pulpwood industry is moving rapidly toward three principal goals: 1) to grow more timber, and grow it cheaper and faster; 2) to harvest the timber more efficiently; and 3) to strive for closer utilization of each tree cut and

[2] An abstract of a paper by J. A. Holekamp "Recent Developments in Portable Harvesting Equipment," given at the Mid-South Section Meeting, October, 1959, and approved for publication, August, 1960.

THE JACKSON TERRAINMASTER is a four-wheel-drive, rubber-tired tractor used to transport loaded pallets from swampy cutting areas to dry truck-loading sites. The pallets are loaded by hand and then winched onto the Terrainmaster, which makes a 9- to 10-ton payload, consisting of two pallets.

THE HARRISON PULPWOOD HARVESTER is a conventional farm tractor with front wheels removed, having a quick-acting loader with three-fingered grapple and positive operator control. One man operating the Harrison can load heavy bolts onto a 1.6 cord capacity pallet at a rate equal to three of the best hand loaders.

each forest acre harvested: If wood fiber is to retain its present favorable competitive position as the principal raw material for pulp and paper manufacture, and if wood fiber and forestry are to be made competitive against inroads by substitutes and synthetics, we must fulfill these goals.

We are faced with two immediate pressing challenges: to learn how to derive more products and more sales dollars out of the raw material we bring to our mills, and to apply techniques of more efficient manpower usage. More simply stated, this means more wood with less men. The objective is one of keeping wood costs in line.

Demand for pulpwood in the South has climbed steadily upward for the past two decades. Projections point toward a continuation of this trend. In contrast, a glance at statistical data on Southern rural-farm population reveals a significant down trend in our principal source of pulpwood labor. We are therefore faced with the challenge of increasing manday production levels (manpower involved in cutting, handling, and transporting from standing tree to unloading truck at mill or transfer into railroad cars) far above the average 1.7 cords, an accepted manday rate for roundwood production in the South today.

Closer utilization after harvesting can be as important as growing the tree in the first instance. For example, by bettering today's level of utilization of raw wood intake into our mills, we automatically increase the productivity of our labor force in the woods. Closer utilization of what we bring to the mill can help yield a higher margin for risk and profit in logging, which is vital to an increase in the productivity of our labor force. In turn, higher margins can provide fresh capital for investment in mechanical equipment, incentive to competent workers, and can prove to be a potent force in attracting trained and qualified supervisory leadership. We look to closer utilization to yield significant revenues, otherwise being wasted, which will pay the cost of a badly needed program of research and development, especially in our harvesting and utilization phases of forestry.

Northeast

The outstanding development in the Northeast is the shift to wood procurement by completely independent logging firms that supply different products to a variety of industries. This has been going on for some time, but during the past year it has expanded very rapidly. It makes sense from almost every standpoint. The independent loggers are able to equip themselves for efficient operation for a given set of conditions, and then to pick the jobs where their equipment will function best. They are also able to build up a knowledge of the best markets for the various products obtainable from trees cut.

The wood-using industries in the Northeast are learning to depend on such loggers, and more and more of them are issuing clear specifications and price lists for the products they desire. Observations were made at a number of specialty plants recently, where this system has practically solved tough procurement problems. One plant in New England, which utilizes white birch, has trained the local pulpwood loggers to recognize good turning bolts. These are stacked on the back tier of the truck and dropped off at the turning plant for half again the price of pulpwood. The rest of the load then goes to a nearby pulpmill. Another example is a dimension plant in West Virginia that is buying selected hard maple and black cherry bolts from pulpwood loggers. This firm pays about twice the price of pulpwood for the cherry, and half again pulpwood rates for the maple. Once again, the loggers drop off the selected material enroute to the pulpwood yard.

One company in New Hampshire, whose sole requirements are selected hard maple logs, sells stumpage on company lands to independent loggers and buys back only the logs it wants from them. Company foresters, however, assist the loggers to market the rest of the products to other industries.

Logging in the Northeast is becom-

VIBRO-VERGEN snow compactor displayed at University of New Brunswick forest. (Courtesy Woodlands Review, Pulp & Paper Magazine of Canada.)

BOMBARDIER Red Ram and pulpwood trailer. (Courtesy Woodlands Review, Pulp & Paper Magazine of Canada.)

PULPWOOD HARVESTING in the Tennessee Valley area with the "Big Stick," a 4-foot boom and winch with 250 feet of cable powered by the truck engine.

ing more and more a specialized business requiring relatively heavy investments in equipment in order to be competitive. Several foreign visitors this year have been impressed by the high ratio of equipment costs per man in the region and the consequent high level of productivity per man. Tree-length logging is becoming the rule rather than the exception, particularly in hardwoods. This has many advantages, not the least of which is the opportunity to do a more intelligent job of bucking when this work is concentrated at the landing rather than scattered through the woods. It is also a more economical and safer way of doing the job.

The trend to rubber-tired four-wheel-drive skidding machines continues. Of particular interest is a mountaintop hardwood operation in West Virginia where hardwood tree lengths are skidded directly to the mill, a distance of 2½ miles over rough bulldozed trails. A round trip was made by the wheeled skidder in about an hour and a quarter. Bunching was done by crawler track machines over distances up to ½ mile. Use of trucks and loaders for log transport was abandoned on this job, and the operator estimates costs of transport have been reduced 40 percent by this change.

At a new hardwood mill in southwestern Pennsylvania, tree-length hardwoods are trucked directly to the mill and debarked and bucked on the mill deck. Any material not suited for sawing is directed to the chipper. About 70 tons of bark-free chips are being obtained per day from a mill with a daily lumber production of 30,000 board feet. Probably half of these chips are being obtained from what would be left in the woods on log-length operations.

Use of Bombardier type tractors also continues to increase particularly for problem conditions and by smaller operators who can only afford to own and run one machine. Road-building needs of such operators are generally met by contracting the work to owners of crawler-track machines.

All this is helping to keep the Northeast competitive with other regions where labor costs are lower, and logging conditions are more favorable. Much of the progress, it is felt, has been brought about by the activities of the Northeastern Loggers Association, including the Annual Loggers' Congress.

The hardwood industry generally has been quite prosperous and operating at a fairly high level of production throughout the year. Much of this has been due to the heavy demand for hard maple for bowling alley parts and pins. Use of maple for this purpose in New York State has tripled in the past 5 years, and it continues to increase. Laminating and plastic coatings have made it possible to use heartwood as well as sapwood and to obtain suitable material from No. 2 Common lumber. The heavy demands of the bowling industry on the supply of hard maple have caused other industries, including furniture manufacturers, to use other species, notably soft maple and beech.

In contrast to the hardwood industry, the softwood industry in the Northeast has been pretty much in the doldrums, as it has in other regions. This is due not only to the low level of construction activity, but also to the inroads of substitutes. One exception is the continued good market for tight, red-knotted, white pine, which is being used for furniture and panelling.

Northwest

Transportation: A significant trend in the Northwest is the transition from rail transport to truck transport of logs. The reasons have been primarily economic, but equipment and method development have also been responsible. The recent introduction of a prelead logging trailer is one example of such development. This unit incorporates a truck and two-8-wheel trailers. One trailer is loaded, or being loaded, while the other is in use. On return trips, the trailer is carried 'piggyback' on the body of the truck. The trailer can be loaded and unloaded from this position by conventional log-handling cranes. According to the operators of this equipment in British Columbia, hauling production has been doubled.

Logging Safety Institute: A logging safety institute held at the College of Forestry, University of Washington, in February, 1960, was so successful that a similar program was held in February 1961. The institute was co-sponsored by the Pacific Northwest Loggers Association, which is also sponsoring an institute this year in cooperation with Oregon State College.

Skylines: Another interesting development is the trend to skyline logging. Although existing systems are largely experimental, increasing interest is being shown in the potentialities

THE BUSCH COMBINE is a four-wheel-drive, rubber-tired tractor which can fell, delimb, buck, package, and transport 5-foot pulpwood. Manday production rates of 10 cords and more (stump to car) are the objective of this basic research effort. A sister to the machine is the forest management tool called the Buschmaster.

THE BOMBARDIER with pallet trailer is being tested as a machine for logging thick stands of gum and swamp hardwood species. The trailer carried a single 10-foot pallet which can hold 3.2 cords of heavy hardwood pulpwood. The Bombadier is outfitted with a unique loading hoist which can yard and load heavy bolts.

of this method. The main advantage—common to all of these systems—is that they permit logging of previously inaccessible areas where steep slopes prevented economical road construction and the use of conventional logging equipment.

Last year's annual review reported on the Skagit skyline system at the Pugh Ridge Company in Washington. Since then, three additional Skagits have been put in use in Oregon, Idaho, and British Columbia.

Two Wyssen skyline units, of Swiss manufacture, have been operating successfully at the Widgcon Creek Logging Company in British Columbia. (See Cover photo). This system differs from the Skagit in that both carriage movement and the operation of tong lines are regulated by a single motor located at the top of the skyline. Strips of 1 mile in length and 300 feet in width have been operated with an unsupported skyline. Production of 50,000 board feet per day has been reported with a 5-man crew. Of particular interest is the light weight (750 pounds) of the carriage and the self-positioning feature of the yarder on the slope.

Another transport innovation is being used by the Crown Zellerbach Corporation, Seaside, Oregon. In this system, the material is cut by contractors but loaded and transported by the corporation. The loading and hauling phases of logging involve large capital investments that many cutting contractors cannot handle. The loading phase is the crucial point insofar as a smooth-running logging operation is concerned, and proper equipment is needed. Crown Zellerbach believes the equipment can be better supplied by the corporation, and the idea has been readily accepted by the contractors.

A third type of skyline system, the Wilko MKV, was installed in the Alberni Watershed region of British Columbia. This unit consists of a single skyline that operates solely from a 110 H.P., propane-powered motor housed in a 5-ton remote controlled carriage. The unit has a 15-ton payload capacity, and covers a strip up to 500 feet wide. Production of 25,000 board feet per day is reported with a 3-man crew.

Research and Development: The Vancouver Laboratory of the Forest Products Laboratory of Canada is continuing its program of logging research. Extensive investigations into the merits of pre-logging versus re-logging have been carried out. Results indicate that pre-logging is more efficient because excessive amounts of breakage and waste occur during re-logging. In addition to this work, log- and tree-grading studies are being carried out on white spruce and other species.

Of particular interest to users of logging equipment is the research work on traction and steering being carried out by the Food Machinery and Chemical Corp., of San Jose, California. The corporation developed a research vehicle that was so flexible it could be adjusted or modified to evaluate 17 drive and steering combinations. It also permitted the selection of the two principal means of traction; that is, the wheel and track.

Lumber Manufacturing—1960

JOHN K. BARROW, JR.
Chairman, Manufacturing Methods Subdivision, Mechanical Conversion Division

THROUGHOUT NORTH AMERICA lumber mills stepped up their production to meet the demand that was to have been generated by the "Soaring Sixties". However, this demand did not materialize. If the present trend continues, lumbermen can well view this decade as the 'Sad Sixties".

According to estimates of the National Lumber Manufacturers Association, lumber production for 1960 will be four percent below 1959. Largest production decreases are reported in the Southern Pine, Appalachian, Central, Southwest and Douglas Fir region. Canadian Douglas Fir, Eastern Canada and the Lake States report relatively stable production as compared with the previous several years.

The National Lumber Manufacturers Association further estimates that lumber consumption will be down four percent from 1959. All regions reporting indicated a decline in demand, a condition that became increasingly acute as the year progressed. The cargo mills of the Canadian Douglas Fir region were able to offset the lack of demand in North America with an increase in their overseas sales, particularly to the United Kindom.

This picture clearly shows lumber consumption and demand dropping more rapidly than production, resulting in a relentless pressure on lumber prices. This condition became more serious during the second half of 1960, especially during the last quarter of the year.

Industry Problems

Lumber manufacturers have become aware of shrinking demand, lower prices and curtailed production. These men now realize that whatever the level of residential building may be, competition from materials other than lumber is constantly increasing. They know full well that an increase in the construction of one and two family housing units could very well not mean an increase in lumber usage, but rather could mean an increased demand for plywood and fibre board to be used as sheathing; plywood and particle board to be used as underflooring, and aluminum, plastics, and other non-wood products, for siding.

Lumbermen are also doing some soul searching. They are even taking a care-

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In 1960 the lumber industry was confronted with shrinking markets, lower prices and curtailed production. Despite this very desperate situation, lumbermen are thinking positively. They are thinking in terms of more modernization and automation, more research and development and more trade promotion. Lumbermen don't rule out the possibility that radical departures from traditional business activity may be necessary before this situation rights itself.

ful look at facets of their industry that have heretofore been taken for granted. They are asking such questions as:

"We know that a board of standard thickness is stronger and has more nail holding capacity than competing products, but what are stronger boards with greater nail holding capacity worth piled in your lumber shed while competitive products take over your markets?".

Lumbermen are asking: *"Can the thickness of boards be further reduced in order to meet competition? Can flooring be made thinner? Can casing be made narrower? Can siding be primed at the mill? Can we produce lumber sizes, lengths and grades that our customers want and need, rather than continue manufacturing lumber in the same old way, insisting that our customers buy what we produce?".*

Lumber manufacturers realize that in an economy capable of producing an over abundance of practically everything, they can no longer think in terms of increasing prices to take care of rising costs, but rather they must think in terms of ways to either cut costs or more fully utilize the raw materials contained in saw logs. These men are thinking positively. They are thinking in terms of more modernization and automation; they are thinking in terms of more research and development; and they are thinking in terms of more and better sales promotion.

Modernization and Automation

During 1960, all areas report an increase in the number of debarkers and chippers. Riderless carriages and gang saws continue to enjoy increasing popularity. The Scotch Lumber Company of Fulton, Alabama has recently installed a tandem gang sawmill equipped with two gangsaws, a debarker, chipper and chip screen. Push button edger setting has become more prevalent in the Douglas Fir regions of the United States and Canada as well as in the Southeast. The number of straddle carriers and fork lift trucks in the lumber industry continues to increase. Of particular note is the trend toward above-ground dry log ponds and automatic live decks in order to make available the use of heavy duty log-handling equipment, such as cranes and large fork lift trucks.

Missing from reports of most regions is activity in the development of equipment for harvesting trees of smaller size and/or in scattered stands, conditions which are becoming more prevalent in practically all of the producing areas. Research and development in this area is urgently needed.

An outstanding example of modern sawmill design and the adaptation of this concept to local conditions is the new ultra-modern plant of Gillies Brothers and Company Limited of Braeside, Ontario. This sawmill was literally moved indoors so that regardless of outside weather conditions operations can be maintained on a year round basis instead of on a seasonal basis normal to that region.

The Southern Pine Association has announced that its 1961 Machinery Exposition will be held at the Municipal Auditorium at New Oreleans, Louisiana on April 7, 8 and 9. Improved logging and lumber manufacturing machinery, including automated timber harvesters where human hands do not touch the trees, will be on display. Attendance in excess of 2,500 is expected.

Utilization of Mill Residues

Wood residue utilization is proceeding at a rapid pace. W. R. Warner, Warren, Arkansas, Chairman of the Southern Pine Association's Mechanical Efficiency Committee, reports that 700 Southern Pine Mills are equipped with debarkers and chippers and that these firms account for nearly fifteen percent of the raw material used in manufacturing paper in the Southeast.

It is reported that an Arkansas mill is producing pulp from dry pine chips. In Idaho, green sawdust is being converted into pulp by means of a continuous digester. In Florida, pulp is manufactured on a commercial basis from sawdust made by circular saws fitted with a smaller than normal number of teeth cutting a wide saw kerf.

Ground bark is made into soil conditioners, mulches and fertilizers by sawmills in California, Oregon, Idaho and several states in the Southeast. The Oregon Forest Products Research Center reports that it has developed a process for making floor tile from ground bark.

In the Douglas Fir region of the United States there has developed a trend for medium size sawmills to pool their resources in order to finance the building of particle board plants and thereby extend plant residue utilization. The Wood Fibreboard Company of Albany, Oregon is typical of an enterprise of this type.

Research and Development

Interest in research and development has been noteworthy in all producing regions. During 1960, the Georgia-Pacific Corporation expanded its laboratory in Hillsboro, Oregon for general research in wood products. The Forest Products Laboratory of Canada increased its personnel in Vancouver, British Columbia, and the British Columbia Research Council made a study of manpower efficiency on green chains. Sawmill clinics were conducted by the Arizona Development Board.

The Columbia Research Center and the University of Missouri School of Forestry has some 60 research projects in progress. A new and modern wood products laboratory was opened at North Carolina State College in Raleigh, North Carolina. There are reports of a new laboratory at Rockville, Maryland to test new methods and techniques for home construction.

At Ottawa, Canada, the Dominion Forest Products Laboratory had an active research program with emphasis on sawing accuracy and lumber drying methods.

Conclusion

The lumber industry is faced with shrinking demand, lower prices and curtailed production. It is a desperate but not hopeless situation. The lumber industry is acutely aware that it has these problems and is actively seeking satisfactory solutions.

There are certain tools at hand, among which are modernization and automation, utilization of mill residues, research and development and trade promotion.

Radical departures from traditional activity may be necessary in the lumber industry before this situation rights itself.

Progress in Wood Drying—1960

ERIC L. ELLWOOD
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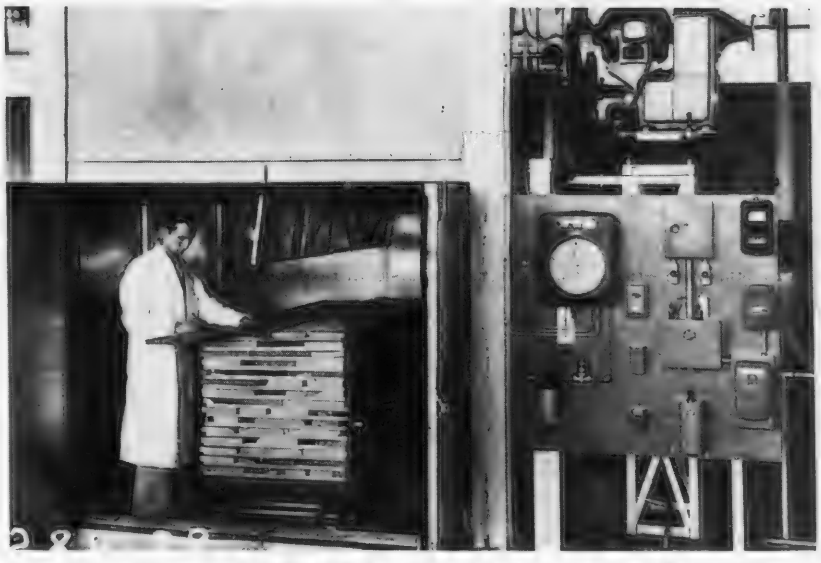
THIS REPORT includes contributions from 19 members of the Forest Products Research Society in various parts of the United States and Canada. Sections on Europe and Australia were based on material prepared by W. H. Brown, London, England and G. W. Wright, Melbourne, Australia.

The review and the bibliography cover developments in research and industrial practice since the comprehensive 1959 report (134). In addition to the references cited in the text by numbers in parentheses, other references are also included as supplemental bibliography.



LABORATORY DRY KILNS are being used to a greater extent for drying studies.

Fundamental Research

In spite of the fact that the fundamentals of wood-liquid relations are still imperfectly known, and that most wood drying operations are empirically based, the amount of effort being put into fundamental research leaves much to be desired. Such studies could contribute greatly to the search for important breakthroughs which may reorient wood drying to 20th-century technology. Also, progress in related fields might be applied to better advantage.

Recent contributions of note have been made on sorption, liquid movement through wood, wood and fiber drying stresses, electrical properties of wood, and the mechanism of collapse.

In an intensive study on sorption, Christensen and Kelsey (45, 46, 47, 107) determined that the sorption of water vapor by wood could be regarded as an additive effect of sorption by wood constituents, with cellulose accounting for 47 percent, hemicellulose, 37 percent, and lignin, 16 percent of the total. The sorption isotherms, except for hysteresis, were similar for all constituents. On the basis of rate of sorption studies, these workers also concluded that, since sorption rate decreased with increasing vapor pressure, rate of diffusion was not the factor controlling sorption. The authors advanced an explanation of sorption in terms of stress relaxation within a swelling gel. Malmquist (127) also advanced a space theory of sorption which explained hysteresis. Other work on sorption included a review by Kollman (111), sorption at elevated temperatures by Noack (146), and sorption in salt-treated woods (112), a study of the part which cellulose, hemicellulose, and lignin play in moisture absorption and swelling (142, 143, 152, 170, 171).

Oberd and Hossfield (150) examined the swelling of wood in a dioxane water system to explain the variable swelling obtained in terms of modification of hydrogen bonding by the dioxane. Also, Horrike and Kato (90) examined wood swelling in relation to hydrogen bonding.

Tarkow and Stamm (196) experimentally determined the diffusion of gases and water vapor through air-filled, softwood capillaries, and found that transverse gas diffusion through pit pores was approximately 40 times less than predicted from the Stamm electrical analogue equation in which free diffusion was postulated. In the fiber direction, the diffusion coefficient was similar to the calculated value. It was further found that moisture diffusion in the transverse direction could be predicted from the diffusion constant of CO_2, indicating that moisture is moving as a vapor in wood of low moisture content. Stamm (190), in another paper, obtained bound water transverse diffusion coefficients by direct measurement and from electrical conductivities of wood in the transverse direction.

Several investigations on the mechanics of wood permeability were reported (45, 46, 58) as well as work on the anatomy of wood as it relates to wood permeability (51, 96, 163, 192, 193).

In the field of drying stresses, work was done on stresses developed during high-temperature drying in oil (175, 201). Some consideration was given to stresses developed between different types of wood tissue by Schniewind (174) who discussed drying stresses in terms of a) stresses developed within cell walls, b) stresses developed between different tissues, and c) bulk stresses in whole wood resulting from moisture gradients. Investigations on creep and stress relaxation are helping to unravel the complexity of wood shrinkage and drying stress behavior.

Investigations on the mechanism of collapse were made by several investigators. Kauman (101) investigated the relative influence of drying stresses and liquid tension on collapse and established a formula to predict the relative importance of each in drying a particular species. He also investigated the effect of collapse reduction in eucalypts treated with inorganic salt solutions (102). Cortes and Kauman (50) reported reduced collapse in wood by treatment of inorganic salt solutions, following reports by Chudnoff of re-

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duction in collapse by treatment with acidified $ZnCl_2$.

Ellwood, Ecklund, and Zavarin (62) described investigations in which reduced collapse was obtained by using organic liquids selected for surface tension molecular weight and polarity. Liquids with low surface tension substantially reduced collapse even when specimens were oven-dried from the saturated condition. Other specific effects of certain liquids on reduction of shrinkage, especially when the specimens were dried under severe conditions, were also noted.

Bryan's (44a) report on collapse recovery in madrone showed the unusual property of high recovery from collapse at low moisture contents when the wood was reconditioned.

Some attention was also given to electrical properties of wood insofar as their relationship to moisture content is concerned (12, 54, 108, 120, 162). The problem of obtaining an accurate relationship between moisture content at high temperatures and direct current is still unsolved. (Skaar suggests the possibility of using audio-frequency alternating current instead of direct current.) One approach by Uyemura (209, 210) investigated the use of dielectric constant variation at radio frequencies, which should be useful for measuring moisture content above the fiber saturation point, where the effectiveness of the resistance meter is limited.

Another technique of moisture measurement receiving attention is the use of radioisotopes (147). This method has the advantage of measuring high moisture values, but the problem of normal wood density variation and shrinkage precludes accurate measurement. Radioisotope moisture measurement may be practical, however, in veneer drying.

Preseasoning Treatments

A discussion of the cause of chemical brown stain of sugar pine and Idaho white pine and the research conducted by Western Pine Association to develop sodium azide as a control has been published by Stutz (194, 195). Commercial use of this treatment is expanding, and sawmills are making considerable savings from the shortened kiln schedules made possible with the treated stock. Work is continuing to explore the potentialities of similar methods of stain control for stain-susceptible hardwoods. Chemical brown stain in southern hardwoods was also discussed by Bois (32).

Further information on economies effected by using wax-emulsion end coatings prior to air drying has been made available by Shore (179) who studied end coatings for redwood. The wax-emulsion type of end coating was the cheapest in over-all cost of application ($0.53 per mbf), and savings resulting from reduction of end checking amounted to $6.60 per mbf. Manufacturers of other species and hardwood dimension are showing increasing interest in end coatings of this type for air drying. One mill has reported an annual saving of $17,500 on a 15,000,000 board-foot cut merely by reducing end trim an average of 2 inches (26).

Work by Mitchell and Wahlgren (139), in which polyethylene glycol was used to stabilize gunstocks dimensionally, gives some indication that this chemical may have promise for chemical seasoning of refractory wood.

A study showing that decay and fungus stain in birch and maple logs are prevented by continuous water spraying was described by Lane and Scheffer (122) and for western hemlock by Wright, Knauss, and Lindgren (222). Such decay and stain are wasteful in sawlogs, and very serious in high-value veneer logs.

Results indicating that chemical stain of redwood may be reduced by steaming at atmospheric pressure prior to kiln drying have been published by Ellwood, Anderson, Zavarin and Erickson (1, 59, 60). A pilot study to evaluate the process on a commercial basis is being undertaken by a redwood mill.

A corollary result of steaming in laboratory tests to reduce stain indicated that the drying time of the presteamed stock was substantially shortened when it was either air-dried or kiln-dried (23). Similar reduced drying times for presteamed eucalyptus were reported by Campbell (41; see Australian supplement) in contrast to results previously obtained in Britain on presteaming European beech for which the reduction in drying time was negligible. Perkitny, Lawniczak, and Marciniak (161) investigated the effect of presteaming on swelling pressure and established that swelling pressure (confined) is reduced. This may explain the reduced working of presteamed beech. Another study on the effect of steaming beech was done by Sobczak (188).

Air Drying

Much lumber produced in the United States is still air-dried. In this country, as in Canada, there are great efforts to improve the efficiency or operation because of competition for markets and the fact that FHA and other governmental agencies have put moisture content regulations into effect. The need of better seasoning for development of new markets is widely recognized.

In the south many operators are surfacing all or part of their yards in an endeavor to obtain more uniform drying, and several have increased their yard area to accelerate drying. There is also some interest in presurfacing of lumber as a means of achieving faster drying rates and uniformity of drying. A study on presurfaced 4/4 oak, under the auspices of the Macon Research Center, is in progress. A closer look is also being taken at the drying rate and degrade of hardwood species, such as oak, gum, and poplar.

In the Rocky Mountain area and the southwest where many small mills are appropriate for air-drying, some problems exist because of failure to follow good practices. Further advances are necessary to support the efforts being made to reach new markets that require closer control of moisture content. The most common shortcomings of present air-drying methods are poor yard layout, inadequate pile foundations, poor sticker alignment, and failure to use pile covers. Especially in the southwest, losses due to poor cover can be high, as shown by Peck, Kotok, and Mueller who found that losses per pile resulting from lack of covers ranged up to 5.6 percent in the upper grades of ponderosa pine.

Increased production of heavy roof and ceiling decking from relatively small-diameter lodgepole and Englemann spruce logs containing substantial amounts of boxed heart has focussed attention on sticker alignment and spacing in an endeavor to reduce inherent twist and warp. Also, some attention is being given to the problem of end checking in logs in the southwest. Air-drying practices for the pole-producing industry are under consideration because premature failures in treated poles in many instances have been traced to improper seasoning which resulted in seasoning checks penetrating through the treated zones.

In the west, ways and means of reducing degrade and obtaining faster air-drying rates are continuously being studied in the humid redwood area. There has been much discussion on the optimum sticker thickness for air drying under relatively humid conditions, bearing in mind that drying is completed in kilns. Some operators have

adopted ½-inch thick stickers, but success with these stickers has not been universal. The importance of good segregation on the green chain as an aid to fast and uniform drying is also receiving more attention.

Smith and Berolzheimer (184) studied the air-drying of incense cedar in 3-inch thick planks cut for pencil slat manufacture.

A study by Headlee (86), Clark and Headlee (48), and Brown (36) demonstrated the economic benefits of roofing the air-drying piles.

Forced-Air Drying

While it is encouraging to note the alacrity with which the industry generally is reacting to the need for improvement of air-drying by adoption of forced-air techniques, it is probable that undesirable repercussions may follow unless more thought is given to the use, design, operation, and economics of forced-air driers. It is symptomatic that the rapidly increasing use of forced-air techniques has been accompanied, in some instances, by exaggerated claims, doubtful new fundamentals of drying, and little regard for engineering or wood drying principles. Essentially, the same principles of drying apply for forced-air drying as for any other method involving air circulation. Some of the questions deserving close attention are: 1) Should heating units be used to maintain an adequate wet bulb depression when air paths are long? 2) Should not heating be used if, in fact, the greatest gains are to be made in areas or periods of high humidity? 3) If heating is to be used, what part should recirculation play in reducing operating costs? 4) At what point is it economical to make the transition to conventional kilns? Objective studies on drying degrade and uniformity of drying, particularly for hardwoods and slow-drying species, are also needed.

The question of terminology is also involved. Currently, the terms predrying, accelerated air drying, fan drying, induced air drying, low temperature drying, and forced-air drying are all used to describe the one operation. It is contended that the term forced-air drying should be used to describe the acceleration of air through lumber stacks without control of humidity. Low temperature drying should be applied to describe forced-air drying using heating units when the objective of the heat is either to accelerate drying or to maintain a suitable wet bulb depression, but with the proviso that the low temperature drying is not capable of completing the drying to a low final moisture content and does not have the capability of sufficient control to provide equalizing and conditioning treatments. Both types of units can be classified into portable or nonportable driers.

Perhaps the most activity in forced-air drying is taking place in the south and midwest, with emphasis on the drying of pine and hardwoods. More southern operators in the vicinity of big cities are looking toward forced-air drying as a means of solving the problem of yard space. Design of set-ups or units ranges from open-air, ½-HP attic fans with canvas baffles to permanent shed-type buildings provided with heating coils as well as full-size fans. Several companies now offer forced-air units for sale. As one example, it is reported that for an open-air, forced-air drier operating in the midwest, the capital outlay for canvas baffles, supports, and two 48-inch fans driven by ¾-HP was $500. The unit is operated for 9 months of the year and dries 4/4 soft maple to 18 to 20 percent in 10 days in drying weather, or in double that time if humid weather occurs. The greatest savings were shown during the hottest (and also the wettest) months of the year. Drying was not satisfactory at temperatures below freezing. The estimated saving was $1 per 1,000 bd. ft., taking into account reduced drying degrade as compared with that for air drying.

A significant move in the last year has been the application of forced-air drying to oak and gum crossties (92). The drying time has been reduced to one-third of that for conventional air drying. At least one southern wood-treating plant is using this technique.

Comparatively few technological reports on forced-air drying have appeared among articles published on this subject in the last year (22, 35, 56, 182, 183, 199) although investigations are underway in several places. The University of Florida is comparing forced-air drying, covered air drying, and conventional air drying. The Southeast Forest and Range Experiment Station is continuing studies on forced-air drying variables. In Canada, the Ottawa Laboratory is currently studying the forced-air drying of 2-inch yellow birch, and in the midwest, investigations are being made on the role of heat in forced-air drying. The University of Massachusetts is also installing a forced-air drying unit for investigation.

It is highly probable that the increasing use of forced-air drying will eventually stimulate the construction of dry kilns as more operators obtain first hand experience of accelerated drying.

Kiln Drying

The action of FHA and other agencies, such as the Southern Building Codes Congress, has sharply focussed attention on the need for better drying. This, combined with the need and desire of lumber companies to develop their existing markets and to find new outlets, has stimulated an increase in new dry kiln construction and modification of existing kilns. An interesting survey of the industry position on seasoning was made by *The Lumberman* (24). Of 222 mills with dry kilns reporting, the great majority envisaged that they would be increasing their kiln capacity within the next few years, and that kiln drying increased salability and profits. The survey also indicated that orders for kiln-dried lumber are substantially increasing.

There is a marked trend toward unit package kilns which are loaded with fork lifts. Overall, there is considerable interest and development in handling as one solution to the profit squeeze in lumber production and to the improvement of drying quality. To gain these objectives, better stacking is being obtained through increased use of mechanical sorters and stackers. Warping is also being minimized by better stacking. Use of sorters, stackers, and unstackers is reducing handling costs in many plants. There is considerable interest in direct-fired kilns because of their lower initial and operation costs as compared with those of steam plants. In the last 5 years, the increasing market for wood residue, mainly in the form of chips, has caused many operators to convert to gas and oil for steam production.

The interest in prefabricated kilns appears to be increasing. From Canada, it is reported that several new kilns of British design have been installed and are working very successfully. An unusual portable kiln holding approximately 36M board feet, designed to cover the needs of the small operators, is being marketed. The kiln is direct-fired and is designed to run on tracks set on a concrete slab. In effect, the kiln is moved to the lumber rather than the lumber to the kiln. There is a trend toward fans and motors that will produce higher air velocities through the kiln charge, thereby reducing drying time. Technological studies on air circulation were made by Bollman (33) on the economy of drying with and without fans, Hedlin and Hooper (88) on heat transfer, and Kollmann and Schneider (113) on air velocities in steam and hot air mixtures. Gardner (75) discussed the theory and practical benefits of drying by means of air streams directed normally to the drying sur-

SOLVENT SEASONING shows promise for drying impervious or refractory woods. This pilot plant shows drying chamber at left and still and storage tanks at right.

face. Salamon (172) reported on air circulation studies of 11 industrial dry kilns and Malmquist and Meischner (129) on cross-circulation tunnel kilns.

The U. S. Forest Products Laboratory has issued a new report on kiln drying schedules (204). Hardwood schedule recommendations are essentially unchanged. Throughout the southeast the Forest Products Laboratory schedules for refractory hardwoods are generally followed. Softwood schedule recommendations, using moisture content as a basis, have been changed considerably. Time schedules used by industry for softwoods have been listed in a systematized manner. Extensive suggestions are given for modification of the recommended schedules to shorten drying times and reduce costs when conditions permit. Special schedules for special items and purposes are discussed. The report includes information on equalizing and conditioning, on sterilizing treatments for mold, decay, and insects, and on drying time. The British Forest Products Laboratory also published a leaflet on kiln schedules (17). Several reports on kiln drying of particular species appeared (15, 16, 29, 61, 131, 141, 167, 181).

The importance of minimizing seasoning degrade and obtaining closer control of final moisture content in kiln-dried lumber is being recognized by an increasing number of plants. As a result, dry-kiln technicians are being given more authority and more help. This enables them to study their drying job more carefully and take steps to reduce drying time through better operational and maintenance procedures, without sacrificing quality. Several dry-kiln technicians have reported that modification of basic drying schedules to fit their kilns and drying standards have resulted in shorter drying time with no reduction in the quality of the product.

A technological report by Knauss and Clarke (110) on seasoning and surfacing in kiln drying Douglas fir was published in the northwest. Other studies on seasoning quality on oak, gum and poplar are being done at the Macon Research Center.

From the Midwest, is reported a growing awareness that, with high-quality hardwoods, the first consideration is reduction of drying defects, even if this does require longer drying time.

Custom kiln drying business appears good. At least three of the larger custom kiln drying firms have installed predriers to reduce kiln time. However, some hardwood lumber is being kiln dried green from the saw.

One study on the effect of sticker thickness on kiln drying time was reported by Siimes (180). Also, a few dry-kiln technicians have used stickers of varying thickness during kiln drying. The results reported to date are conflicting—some favoring thin stickers, others favoring the thicker stickers. It appears that more carefully planned studies will have to be made before definite conclusions can be reached as to effect of sticker thickness on drying time, moisture uniformity, and drying costs.

Several western commercial species tend to have a high incidence of wet pockets or sinker material which has substantially lower drying rates than normal heartwood of the species. The practice of green-chain segregation, based essentially on green board moisture content, to aid drying, is most highly developed in the west, and further improvements are being sought. The Redwood Seasoning Committee recently recommended that to reduce overall drying times, 6/4 and thicker material that must be dried should not be cut from heavy logs.

High Temperature Drying

Comparatively little on the high temperature drying of standard lumber sizes has been published within the United States recently (165). High temperature drying does not appear to be gaining ground overseas, but research is still active (116, 125, 126, 130, 135). High temperature drying studies are being made in the Canadian Forest Products laboratories and the Oregon Forest Research Center. At the Vancouver laboratory, high temperature drying is still in the experimental stage—casehardening and honeycombing in 2-inch and thicker material not having been completely overcome. In the Oregon laboratory, some checking occurred just back from the ends of the boards.

High temperature kiln drying of gum crossties at 230° F. for 3 to 4 days has been practiced as regular routine for 3 years by one company in the south. Service tests of high temperature-dried gum and oak crossties installed 2½ to 4 years ago show excellent results. Check size had increased more in air-dried ties than in ties dried at high temperature. At the Ottawa laboratory, green sugar maple crossties are kiln dried to 30 percent moisture content in 50 to 60 hours at 230° F. Although steep moisture gradients were obtained, treatability is satisfactory. The quality of the dried ties was generally good, with major checks and splits absent, for the most part. Internal checking was considerable, however, although it was evenly distributed and was considered less damaging than large checks.

Special Drying Methods

Several pilot studies on special drying methods are in progress but little has yet been published.

Solvent seasoning, which shows promise as a method of drying impervious or refractory woods, is being studied in California. Besides the rapid drying obtained by this method, stress development in the lumber, and consequent degrade are substantially less than is obtained with conventional

drying techniques, at least with the species dried so far. Preliminary cost estimates by Fearing (67) indicate that the process is economically feasible, at least for 4/4 tanoak, but further data are necessary before accurate costs can be determined. Following the drying study on tanoak by Anderson and Fearing (2), a study is now being made on the solvent seasoning of redwood using acetone.

Drying by boiling-in-oil is being investigated at a pilot plant in Bend, Oregon. The main problem (found by earlier investigators) has been retention of oil in the outer shell of the lumber and incidence of internal checking in species not readily dried by conventional methods. In this investigation, West Coast hemlock and white fir studs (2 x 4's) were dried in 10 to 12 hours, almost free from checking, and 4/4 red alder was dried in 5 hours, but with occasional honeycombing. European workers are also active in this field (73, 201). Some vapor drying and solvent recovery drying are being done at wood-treating plants, but these processes have not yet come into general use.

Some work is continuing on the high frequency drying of wood (31, 34, 99, 212), but no new major developments have been published in this field. Kiln drying by solar heat received some mention (20, 25).

Further articles have been published on centrifugal drying (117, 118, 134), which is used to a very limited extent in Europe.

Dry Lumber Shipment and Storage

With the increasing demand for dried lumber at specified moisture contents, more attention must be given to the storage of dried lumber at the sawmill prior to shipment, to protection during shipment, and to holding conditions at the customer's plant. On the west coast, it is not general practice to condition dry lumber sheds at lumber mills to controlled equilibrium moisture content values. However, thought is being given to conditioning sheds by means of exhaust steam from kilns, and installation of moisture-proof floors and other devices for holding down moisture content. In the redwood area, particularly, wrapping of high-quality finished items in moisture-proof wrappers is a general and well accepted practice.

Shipment of lumber by flat car and small-door box car still remains a problem, but wrapping of units for shipment under exposed conditions is being undertaken. In the northwest, the hardwood producers have adopted road trucking to market in Los Angeles in strapped, unit packages with tarpaulin cover in the winter only.

SHORT COURSES ON WOOD DRYING continue to draw large enrollments. Here students from industry examine the quality of lumber dried during a short course at the Forest Products Laboratory at the University of California.

The importance of bulk piling kiln-dried lumber for a short period before use in order to improve moisture uniformity between and within boards was reported by Smith and Dittman (185). They showed that one-week bulk storage of 5/4 ponderosa pine shop showed pronounced improvement in the uniformity of moisture. A second week of storage showed only slight improvement.

Education in Drying

Interest in short courses in kiln drying continued at a high level. A two-week course held at the U. S. Forest Products Laboratory had an enrollment of 42 men, the second highest to date. Large enrollments were reported at one-week short courses held at the Oregon Forest Products Research Center, the New York State University College of Forestry, the University of Illinois Department of Forestry, and the Canadian Forest Products Laboratory in Ottawa. Cooperating in the University of Illinois short course were the Universities of Illinois, Southern Illinois, Iowa State, Michigan, Michigan State, and Purdue, and five firms in the drying field. Now that its new laboratory has been completed, the Vancouver Forest Products Laboratory proposes to reintroduce short courses in kiln drying at least once every 2 years. The University of California Forest Products Laboratory is also programming short courses biennially. The University of Washington is also proposing short courses. A new experimental dry kiln at Colorado State University may be expected to assist in kiln-drying practice in that area. It is also of interest that the National Science Foundation has financed the production of an instructional film on wood drying. The film will be produced at the New York State College of Forestry, the project being instigated by the FPRS Wood Drying Division.

Twenty dry kiln clubs and associations in the United States have meetings at regular intervals. Two joint meetings were held in 1960, one at Missoula, Montana (the eight western clubs), and one at Madison, Wisconsin (between the Midwest and Wisconsin-Michigan Wood Seasoning Associations). The topics discussed covered all phases of seasoning, storage, and handling of wood, and moisture content of wood in use. Several talks were given on the use of forced-air driers and the results obtained from them. Panel discussions were interesting, and resulted in answers to many problems. Usually, one or more plants are visited during these meetings.

More and more of the "men behind the guns"—the dry-kiln technicians—are participating in the meeting programs. They are doing an excellent job in solving problems, giving detailed information on devices they have developed to reduce lumber handling and drying costs, and reporting on their studies aimed at securing lower cost, higher quality, dried lumber. Several of the topics covered at these meetings have been abstracted for FPRS Wood Drying Division's News-Digests. A filing system for past issues of the Drying Division's News-Digests and a list of Digests to date have been prepared (11).

It is apparent in many instances that the effectiveness of the drying operations is limited because of failure to recognize the extent to which handling procedure of the logs and lumber up

to the point of drying can substantially affect lumber drying quality. Also, excessive demands by the mill planing shop for dried lumber can and do have deleterious effects. This points to the need for education of senior management personnel with respect to the nature and problems of drying as well as the desirability of more inclusive responsibility on the part of the drying operators.

As one example of the importance of this aspect, the Redwood Seasoning Committee has recommended that green-chain graders be more fully familiarized with the drying problem to aid in better segregation on the green chain, with consequent benefits in drying.

Seasoning Specifications and Quality Hallmarks

The Lumberman magazine has contributed to improvement in lumber moisture content quality by publishing, in a single issue, a number of articles, Evans (66), Field (69), and Olson (155) on kiln drying and seasoning of wood. In another issue, the editor discussed ways to end the lumber dryness controversy. Currier (52) showed the need for adequate seasoning before finger jointing of construction lumber.

More mills, particularly in the west, have become interested in automated measurement of moisture content of lumber on the dry chain. The electronic moisture meter used for this purpose can be adjusted so that the meter will ink-mark boards that are either above or below the range of moisture content set in the meter.

Smith and Dittman (186) studied an electronic moisture meter that scans a large area of every board on the dry chain. Their research indicated good possibilities for use of such an instrument by industry to maintain better standards of moisture uniformity in dried stock, provided improvements are made in sorting the green material into proper moisture classes, and drying times for each kiln charge are closely controlled. This study incidentally illustrated the point that even under good to excellent drying procedures by commercial standards, the range in final moisture content was much greater than had been supposed.

The moisture content of structural wood members in buildings at a southern site was examined by Hopkins (89).

A recommendation by the Redwood Seasoning Committee on the term "Kiln Dried Lumber" deserves consideration. The Committee felt that the term "Kiln Dried Lumber" should be revised to read "Kiln Dried Stress Free Lumber." It seems logical that when stress relief treatment is done in kiln drying, the terminology should so indicate. Under the present situation, the term "Kiln Dried" simply means to many purchasers that at least some drying has been done in a kiln.

European Research and Practice[1]

Great Britain: The seasoning of timber is becoming more efficient, although the basic technique remains the same. More thought is going into quality control, and consumers generally are more exacting in their demands for reduced degrade in kiln drying. There is an increased demand for small, prefabricated aluminum kilns, which are very efficient and cheap. In view of the ever-increasing price asked for building work, these kilns are proving more economical to the average user. The higher efficiency apparent with this type of kiln is due to the improved insulation made possible with fiberglass, together with automatic control of ventilators, which prevents a serious waste of heat.

Aluminum walls are, of course, completely non-absorptive, whereas brick walls are not. It has been found that many species of timber will withstand higher temperatures, or lower humidities, than was formerly thought possible, and this, coupled with high air speed and automatic reversing every 30 minutes, makes for more rapid drying. Experiments carried out by high-frequency methods of drying have not fulfilled their early promise because of cost of drying and the difficulty of avoiding degrade in refractory species. The British Forest Products Research Laboratory has carried out air seasoning experiments in Scotland, in areas with above average rainfall, and these have provided a striking demonstration of the advantages of proper roofing to timber stacks. A large scale survey of the specific gravity and moisture content of thinnings of seven native-grown softwoods is nearing completion.

France: No real changes have been made in drying techniques in France. Many yards are small, but sticking is reasonably well carried out. The use of hardwood sticks for air drying beech results in stick marks in some instances. In general, this is considered reasonable grounds for complaint on material shipped to the United Kingdom. The high standard of veneer drying equipment, mainly of German origin, was noted in recent visits to plywood mills. The operation as a whole, however, was not impressive, and appeared to leave a lot of room for improvement. This is probably due to the facts that new mills have sprung up, causing a temporary shortage of trained personnel.

A visit to a factory manufacturing chairs from laminated beech veneers, on the other hand, showed a drying chamber of the simplest design that was very successful, although it was operated completely contrary to normal, accepted veneer-drying practice. The works were those of M. Chambeaudie, at Egletons, in the Correze district. (It is perhaps worth recording that, apart from the peeling machine, all other machines at the factory were made by M. Chambeaudie who was producing 3,000 beech chairs per week, together with a large quantity of other types, with a staff of 33 men.) The drying chamber for the veneers is a brick-built, rectangular tunnel, 144 feet long by 12 feet wide, by 6 feet, 6 inches high. Heat is produced from a large, forced-draught boiler, the end of which projects slightly into one end of the chamber. A huge extractor fan is housed in the far end, and this draws the hot air through the chamber. Veneers 1.2 mm. thick are loaded on trolleys, composed of a series of slatted apertures, which are then rolled into the kiln at the heated end. Each day the trolleys are moved toward the cooler end in the fashion of a progressive kiln. Vents in the roof allow moisture to escape. The trolleys are placed sideways so that the hot air passes across the faces of the veneers without being impeded by the dividing slats. At about two-thirds the length of the chamber, the trolleys are turned, so that the full draught created by the fan is reduced across the veneer faces by the cross slats of the trolleys. It is only fair to state that uniformity of drying is perfect, with end splitting of the veneers practically eliminated. On the occasion of this visit, it was impossible to find any split or badly buckled veneers. This was a remarkable achievement in view of the unorthodox method.

Russia: Until now, very little information has been forthcoming from Russia regarding technical developments. So far as the United Kingdom is concerned, softwoods brought in from the U.S.S.R. are generally bright and of fairly low moisture content. Occasionally, however, an odd parcel of discolored stock finds its way over, but this is the exception rather than the rule. No hardwoods are imported from this source. Research has been carried out, in the Central Scientific Research Institute of Plywood and Furniture, on accelerating the seasoning of wood chips for particle boards in continuous-belt kilns.

This has been achieved by drying the material on continuous belts of wire mesh arranged in a kiln of three

[1] The author acknowledges with thanks this special contribution on European activities by W. H. Brown, Timber Specialist, Remploy Limited, London.

to five stories. In these kilns, the damp material is fed to the highest stage, and emerges from the bottom fully seasoned. Wood chips of varying dimensions may be handled efficiently, and the material does not undergo any further reduction in size during the process. In belt kilns the air can circulate either in the same direction as the chips, or at right angles, thus passing through them. The research has established that, all things being equal, when the air current is passed through the material, the drying time is 15 to 20 times less than it is when the air moves parallel with the layer.

High Temperature Seasoning in Petrolatum: Research projects have also been carried out on the effects of seasoning in liquefied petrolatum, at temperatures exceeding 100°C., on the strength of glued joints. It was concluded that: 1) The production of internal stresses in timber was identical in principle, in either seasoning in petrolatum, kiln drying, or air seasoning. 2) The particular characteristics of the stress condition of material seasoned in petrolatum show the intensive nature of the process of removing moisture, and the increase in elasticity of the timber at temperatures exceeding 100°C. 3) The production of internal shakes during high temperature seasoning in petrolatum is not a particular disadvantage of the method, and can be avoided by adopting appropriate schedules. 4) The values of latent stresses in timber seasoned in petrolatum are no higher than those arising in kiln-dried timber.

General: Seasoning methods in Denmark, Yugoslavia, and Romania have not changed. Yugoslavia tends to produce steamed beech because that stock appears to air dry quicker than the unsteamed, and there is less likelihood of discoloration in the yard. High demands are made, however, by the United Kingdom, Italy, and Switzerland, for white beech, and this is generally more readily obtainable from France, Denmark, and Romania. Very little packaged softwood is coming out of Europe.

Australian Research and Practice[2]

Present research and industry trends in seasoning in Australia, as elsewhere, are mainly directed toward accelerating drying processes, reducing drying losses, improving dried quality, and extending supply by work on the timber of young trees and marginal species. These objectives, part of a program to improve the seasoning behavior of native and introduced species, now apply as much to the drying of round and sawn timbers (44) needing preservative treatment—a fast developing trend in Australia—as they do to seasoning "dressing grade" products or veneers.

Research Trends: In recent years seasoning research has contributed mainly with developments in, or work on:

1) Presteaming, predrier design, and predrier operation—to give optimum output and quality control.
2) Warp control.
3) Boultonising, steam and vacuum drying, kiln drying, and vapor drying—as partial drying processes for large round and sawn timbers.
4) Equilibrium moisture content relations.
5) Collapse—its prevention and removal.
6) Air seasoning—particularly the influences of yard layout and stack construction on rate and uniformity of drying.

Presteaming (41) is proving a most successful development in reducing drying times for the difficult Tasmanian "ash" type eucalypts. Laboratory studies have repeatedly given average time savings of 20 to 25 percent, the effect increasing with the more "difficult" (that is, the more impervious) timber; in some timbers drying time was reduced as much as half. Optimum presteaming time for 1-inch thick stock of "ash" type eucalypts (particularly *E. gigantea* and *E. obliqua*) is 2 to 4 hours at a temperature of 212°F. Longer presteaming periods increase collapse and make its removal more difficult, without any compensating increase in drying rate.

Work on warp control has been concerned mainly with improving the drying behavior of radiata pine 2 x 4 framing timbers (221). Sawn production from this plantation species is now some 10 percent of total sawn (all species) production in Australia, and the proportion is rapidly increasing. Material containing pith is particularly prone to drying distortion because of the combined effects of spiral grain and a large micellar angle. However, a combination of the following treatments has proved effective: 1) stack weighting (or other restraint) to the equivalent of about 100 pounds per square foot of top stack surface, 2) steaming for some 4 hours (saturated steam) at the conclusion of drying, followed by redrying under weights, and 3) multiple width drying, where practicable, for later resawing to required width.

In studies on equilibrium moisture content, the main emphasis is being given to developing a statistical correlation with meteorological conditions (71). It is expected that the data obtained will enable the prediction of e.m.c. values solely from a knowledge of meteorological history. Factors examined include temperature, relative humidity, wet bulb temperature, wet bulb depression, vapor pressure, rainfall, and wind. Exposure specimens are distributed over a wide geographic and climatic range throughout Australia and New Guinea.

Work on vapor drying (63) is still in progress. A four-year exposure study (not service test) on railway ties of some five eucalypt species, previously vapor-dried with mineral turpentine to moisture contents suitable for preservation treatment, has demonstrated the suitability of the process for eucalypts, and confirmed its effectiveness in holding weathering damage, including splitting due to alternate wetting and drying, to a minimum.

Studies of a fundamental nature which could ultimately have an important bearing on seasoning theory and practice have been continued, and various diffusion and exchange processes have been investigated theoretically (30). It has been found (46, 47) that, under certain conditions, the rate at which very small wood samples absorb moisture is not determined by the rate of diffusion of moisture through the wood, but by an alternative mechanism. This is thought to be associated with the relaxation of intermolecular stresses resulting from the moisture content changes. Studies are also in progress on moisture changes as they effect deformation of wood under stress (27). These effects probably occur also during wood drying, when moisture content changes in the presence of drying stresses. Other phenomena on which these studies may be expected to have a bearing are the recovery of collapsed wood during reconditioning and the use of moisture content changes for the release of stresses—for example, in plywood and other wood laminates.

The problem of collapse is important in Australia, and it is undoubtedly of significance in the utilization of some difficult or secondary hardwoods in the United States. Research on collapse and its recovery is being directed mainly to the clarification of collapse-inducing forces, a determination of the pattern of collapse susceptibility within the tree, and process variables and their manipulation. The parts played by liquid tension and drying

[2] The author acknowledges with thanks this special contribution on Australian activities by G. W. Wright, Officer-in-Charge, Seasoning Section, Division of Forest Products, CSIRO, Melbourne, Australia.

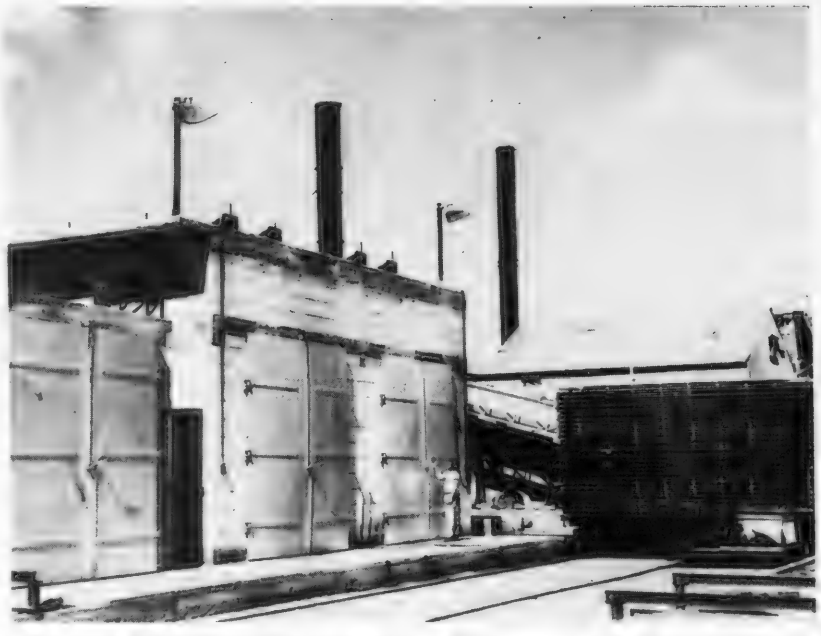
stresses have been elucidated, and their relative contributions are shown in a theoretical formula developed to predict collapse in mountain ash (101). The interaction of drying stresses and collapse has been investigated for timber specimens of various cross-sectional dimensions. Present approaches include studies on the effects of inducing liquids of various surface tensions into the green wood before drying, the induction of gas bubbles into the green wood, the effects of chemical pretreatments (50), the influence of steam pressure and moisture, and the effects of pre-freezing.

Work on veneer drying has been concerned mainly with 1) investigations on the influence of psychrometric and platen (103) conditions on the dried quality (104) of "ash" eucalypt material; and 2) the development of moisture prediction equipment, based on temperature differences, to determine either the drying endpoint in compartment kilns, or the correct feed rate for mechanical dryers. Studies were made on the uniformity of final moisture content at the end of drying. In some cases, it was possible to obtain satisfactory results by over-drying veneers below a specific moisture content, and readjusting moisture content later by special treatment. The influence of peeler-log heating on subsequent shrinkage during drying was also examined (79).

Industry Trends: In the case of hardwoods, the objectives listed earlier have caused a strong move toward more kiln drying and pre-drying—and from higher moisture contents—in an endeavor to reduce stock holding and the resulting capital requirements. This also improves continuity of operations and material availability in areas of poor air drying, and permits a faster adjustment in drying programs to suit market conditions. This trend has also been stimulated by an increasing tendency on the part of timber-using industries to specify moisture content limits.

However, there is an increasing reawareness of the economic benefits deriving from properly planned and operated air seasoning practices. Industry has at last realized that the adoption of mechanized handling and procedures does not, in itself, compensate for indifferent planning or control. The effect has been to stimulate the reconstruction of air seasoning yards, and the development of air seasoning as a process rather than an area of land.

There is also an increasing use of steaming chambers. These are brick or concrete structures capable of taking a full kiln charge. They have as their sole fitting an inlet pipe for live or exhaust steam. These have more than proved their value in Australia for reconditioning collapsed hardwoods and for straightening warp-prone softwoods, but the new trend is for their further use to presteam the slow drying southern hardwoods. In fact, following commercial trials to confirm laboratory results, a number of plants have now installed special presteaming chambers and adopted presteaming as a standard practice. Incidentally, although not strictly seasoning equipment, similar chambers (with watertight, bulkhead-type doors) and vats, called "immunizers," have become a feature of many seasoning plants in some Australian states. They are used for giving dip and soak treatments to borer-susceptible timbers before and during seasoning, to obtain protection against wood-borer attack later.



AUSTRALIAN KILN INSTALLATION equipped with Christensen truck and transfer system for loading and discharging kilns. At left is a steaming chamber.

For softwoods, the trend is to kiln dry from the green condition at high temperatures below the superheated steam range. Superheated steam drying has not generally found favor.

Predriers (218) of large capacity and low cost, and heated drying chambers with forced-air circulation, capable of being precisely controlled, have now been widely accepted in Australia. In the Australian view, the role of the pre-drier is primarily to supplement, or substitute for air drying as a preliminary to kiln drying, particularly for the slower drying hardwoods, where air drying conditions for the latter are unfavorable. Where conditions for air drying are favorable, predriers are thought to become competitive only 1) if proper drying requirements are ignored; 2) where a marked climatic variation occurs to warrant their use seasonally (in which case they may be used as kilns for final drying during favorable air drying weather); or 3) where some special conditions exist, such as an insufficiency of yard space or a particularly unfavorable site. Under the latter conditions, however, a premium is being paid.

These moves have tended to improve production control and to hold down demands on working capital, but they have also tended to increase seasoning costs (because of additional equipment, power, and heating), to increase the risk of downgrade and moisture gradient problems as well as subsequent processing problems in the difficult hardwoods. Fortunately, they have also brought a growing recognition of the need for higher standards of seasoning technology.

There has, as yet, been virtually no move to side-loading kilns despite the wide use of fork lift trucks, mobile jib cranes, and the like in yard handling (220). Preferred practice is to use mobile handling equipment to keep inward stacks moving to, and kiln stacks moving from, a small storage or surge area at the kiln site. The actual loading and discharge of a battery of kilns are generally handled by a Christensen truck—a 20 to 30 foot long, 3-foot wide, mobile, hydraulic lifting platform—in association with a transfer system. The Christensen truck is about 15 inches high, moves endwise under stacks, and is provided with a hydraulic ram system whereby its upper surface may be raised or lowered 1½

inches above and below the height of standard stack hobs in yards and kilns. In the raised position, it is used to lift a stack clear of its supports and then move it on a rail system. In the lowered position, it deposits a stack on its support from which it may then be moved clear.

A recent development is the introduction of a "two-way" truck which performs the operations of both the Christensen and transfer trucks; that is, as required, it may be moved in either of two directions at right angles by the use of a second, retractible, system of wheels and axles at right angles to the first.

In the plywood and veneer industry, the trend is to increased use of accelerated drying equipment even at localities where satisfactory air drying conditions prevail throughout the year. Most new dryers are of either the "screen" compartment type (80) or the roller or band mechanical type. Equipment of the moisture content prediction type, referred to previously, has been installed on a number of dryers.

Literature Cited and Supplemental Bibliography

1. Anderson, A. B., Ellwood, E. L., Zavarin, E., and Erickson, R. W. 1960. Influence of extractives on seasoning stain of redwood lumber. For. Prod. J. 10(4):212–218.
2. Anderson, A. B., and Fearing, W. B. 1960. Solvent seasoning of tanoak. For. Prod. J. 10(5):234–238.
3. Andreane, L. 1959. Effect of sticker thickness on drying rate during air drying of redwood. News-Digest, Wood Drying Div., FPRS (August) 2 p.
4. Anon. 1959. Air-seasoning of lumber speeded by new system. South. Lumberman 199 (2484):36–42.
5. Anon. 1959. Automatic green lumber sorter helps reduce lumber handling costs for cedar mill. Lumberman 86 (10):40–42.
6. Anon. 1958. Collapse and recovery. Rep. For. Prod. Aust. 1957/58, 19 p.
7. Anon. 1959. Drying is important step in manufacturing. Lumberman 86 (10):38–39.
8. Anon. 1957. Drying studies. Rep. Commonw. Sci. Indust. Res. Organ. Aust. 1956/57.
9. Anon. 1958. Effect of gamma rays on the hygroscopicity of wood. Rep. For. Prod. Res. Board London 1957, 46 p.
10. Anon. 1959. Errors in moisture determination from borer cores. Wood (London) 25 (1):19.
11. Anon. 1960. Filing system for FPRS News-Digest. News-Digest, Wood Drying Div., FPRS (May) 2 p.
12. Anon. 1960. Fresh water soaking increases electrical resistance of wood. Research News Forest Products Laboratories of Canada.
13. Anon. 1959. How a mill reduces kiln lumber handling costs on a problem terrain. Lumberman 86(10):44–45.
14. Anon. 1959. Individually controlled kilns are key to drying Pacific hardwoods. Speed of processing and stickering are critical items. Lumberman 86(10):46.
15. Anon. 1958. Kiln drying characteristics of foreign woods. Wood-Worker, Indianap. 77(9):29, 38.
16. Anon. 1959. The kiln drying of Obeche. Extr. from Rep. Dir. For. Prod. Res., Lond. 1958 (7).
17. Anon. 1959. Kiln drying schedules. Leafl. For. Prod. Res., Lond. (42 rev.), 15 p.
18. Anon. 1959. Kiln solves problems for many plants. Lumberman 86(10):85, 87–89.
19. Anon. 1959. Kilns are key to quality control. Lumberman 86(10):43.
20. Anon. 1960. Old King Sol in a starring role. South. Building, p. 13, August.
21. Anon. 1959. Prefab aluminum kilns cut drying time 33 per cent. Lumberman 86(10):67.
22. Anon. 1959. Research in forced-air drying of lumber. Extr. from Rep. Stheast. For. Exp. Sta. 1958, p. 7–10.
23. Anon. 1960. Seasoning stain in California redwood. Univ. of Calif. For. Prod. Lab. Progress Report to Calif. Redwood Assoc., July.
24. Anon. 1960. Where the industry stands on seasoning. Lumberman 87 (10):39–43.
25. Anon. 1958. Wood seasoning and preserving. Low cost solar kiln shows promise. Wood-Worker, Indianap. 77 (10):33.
26. Anon. 1960. Year end survey reveals value of end coating fresh-cut lumber. Hitchcock's WoodWorking Digest 62(8):93.
27. Armstrong, L. D., and Kingston, R. S. T. 1960. Effect of moisture changes on creep in wood. Nature 185(4716):862.
28. Astaf'ev, B. A., Belova, E. I., and Smirdin, R. M. 1959. Drying wood impregnated with a solution of ordinary cooking salt. [Russ.] Derev. Prom. 8(3):9–10.
29. Attiwell, P. 1959. Kiln drying of Monterey pine. For. Tech. Pap. For. Comm. Vict. (1):17–19.
30. Bak, and Kauman, W. G. 1959. Theory of electrodiffusion. Trans. Faraday Soc. 55:1109–1121.
31. Bandi, C. 1959. High frequency drying. Timber of Canada 20(10):46, 48–50, 79; Northeastern Logger 8 (10):8–9, 35.
32. Bois, P. J. 1959. Gray-brown chemical stain in southern hardwoods. U. S. Forest Service. Forest Utilization Serv. FUS release 21, 2 p.
33. Bollmann, L. 1959. Wood drying with and without fans: heat balance and economy. Trans. by J. Hardy from Holz-Zentralblatt 83(125): 1521–1524, 1957. Australia CSIRO Trans. 4621, 15 p.
34. Boyce, C. 1959. The use of high-frequency (dielectric heating) in the wood industry. Preliminary report 1: bending and drying small solid oak and beech blanks. Traeindustrien 9 (12): 147–151.
35. Brown, W. H. 1959. The forced air drying of timber. Timber Tech. 67 (2243):364–365.
36. Brown, W. H. 1959. Influence of pile roofs on degrade. Timber Tech. 67 (2244):410.
37. Brown, W. H. 1959. Unsatisfactory kiln drying of timber. Timber Tech. 67(2245):451.
38. Brown, W. H. 1960. Aspects of timber seasoning. [I] Moisture content and wood finishing. [II] Properties of the genus *Entandrophragma*. Timber Tech. 67(2246):497; 68(2249):108, 115.
39. Brown, W. H. 1960. Aspects of timber Tech. 68(2251):181; 68(2252): 227; 68(2250):145–146); 68(2253): 260.
40. Brown, W. H. 1960. The phenomenon of collapse in timber. Timber Tech. 68(2248):65–66.
41. Brown, W. H. 1960. Quality control in the seasoning of timber. Timber Tech. 68(2247):21.
42. Brown, W. H. 1960. The seasoning of building timbers. Timber Tech. 68 (2251):181.
43. Brubaker, W. 1959. End coating studies. News-Digest, Wood Drying Div., FPRS (July), 2 p.
44. Brubaker, W. 1959. Use of thermocouples in measuring temperature—Humidity conditions in commercial dry kilns. News-Digest, Wood Drying Div., FPRS (October), 2 p.
44a. Bryan, E. L. 1960. Collapse and its removal in Pacific madrone. For. Prod. J. 10(10):
45. Buro, A., and Buro, E. A. 1959. Penetration of liquids into wood. Holzforschung 13:71–77.
46. Buro, A., and Buro, E. A. 1959. Studies on the permeability of pine wood. Holz als Roh-und Werkstoff 17(12):461–74.
47. Bystrov, G. P., Zestjanikov, V. M., and Al'ftan, E. A. 1960. The influence of ultrasonic oscillations on the process of dyeing wood. [Russ.] Derev. Prom. (9)2:15–16.
48. Byvsih, M. D. 1957. An automatic drier for box shooks. [Russ.] Derev. Prom. 6(10):5–6.
49. Cameron, J. F., Berry, P. F., and Phillips, E. W. J. 1959. Determination of wood density using beta-rays. Holzforschung 13:78–84.
50. Campbell, G. S. 1959. Can chemical seasoning help the timber industry? Australia. CSIRO Forest Prod. Newslet. 257:1–3.

Erratum

The Literature Citations are not numbered in proper sequence. The first group runs from No. 1 thru No. 50. Because of a typographical error, the balance are numbered 41 through 223. Unfortunately, this error was not caught in time to correct the numbering. The cross references between text and this list are believed to be correct.

41. Campbell, G. S. 1960. Presteaming cuts drying time of "ash" eucalypts. CSIRO Forest Prod. Newslet. 263:1–3.
42. Campbell, R. N. 1959. Fungus sapstains of hardwoods. South. Lumberman 199(2489):115–120.
43. Christensen, F. J. 1959. A limitation of certain vapour pressure thermometers for timber drying kilns. CSIRO Forest Prod. Newslet. 254:6–8.
44. Christensen, F. J. 1960. New drying plant for poles and sleepers. CSIRO Forest Prod. Newslet. 264:1–3.
45. Christensen, G. N. 1959. The rate of sorption of water vapor by wood and pulp. Appita 13(3):112–122.
46. Christensen, G. N. 1960. Kinetics of the sorption of water vapour by wood. I. The effect of sample thickness. Aust. J. Appl. Sci. 11(2):295–304.

47. Christensen, G. N., and Kelsey, K. E. 1959. (1) Rate of water vapor sorption by wood. Holz als Roh-und Werkstoff 17(5):178–88. (2) The sorption of water vapor by the chemical constituents of wood. Holz als Roh-und Werkstoff 17(5):189–203.
48. Clark, W. P., and Headlee, T. M. 1960. It pays to roof your lumber South. Lumberman 200(2492):39–40, 44.
49. Cortes, T., and Casin, R. F. 1959. Air seasoning lumber. Lumberman [Manila] 5(1):11–20, 30.
50. Cortes, R. T., and Kauman, W. G. 1959. Effect of partial or complete replacement of water with various liquids on the intensity of collapse in *Eucalyptus regnans*. CSIRO Div. of Forest Prod., Proj. S.5, prog. rpt. 23, 9 p.
51. Crenshaw, J. 1960. The fine structure of pits of *Eucalyptus regnans* (F. Muell.) and their relation to the movement of liquids into the wood. Aust. J. Bot. 8(1):
52. Currier, R. A. 1960. Finger jointing at high moisture content. For. Prod. J. 10(6): 287–293.
53. Daskovskij, A. F., and Dlin, F. S. 1958. Quick drying Beech boards by a cyclic method. [Russ.] Derev. Prom. 7(11):3–4.
54. Davidson, R. W. 1958. The effect of temperature on the electrical resistance of wood. For. Prod. J. 8(5):160–164.
55. Delmhorst, W. J. 1960. Checking kiln efficiency with an electrical moisture meter. News-Digest, Wood Drying Div., FPRS (October).
56. Devine, J. 1960. Forced-air drying. South. Lumberman 200(2492):28.
57. Dippel, W. 1959. A new method of measuring moisture content in kilns. Holztechnik 39(2):47–48.
58. Ellefsen, O., and Kolboe, S. 1959. The filtration law of Hermans and Bredee, a theoretical reinvestigation of pore size distribution. Norsk Skogind. 13 (6):199–200, 202–203, 205–10.
59. Ellwood, E. L. 1960. The effect of drying conditions and certain pretreatments on seasoning stain in redwood. News-Digest, Wood Drying Div., FPRS (July).
60. Ellwood, E. L. Anderson, A. B., Zavarin, E., and Erickson, R. W. 1960. The effect of drying conditions and certain pretreatments on seasoning stain in California redwood. Forest Science 6(4).
61. Ellwood, E. L. 1959. Kiln drying green 4/4 California black oak [Quercus kelloggii]. Calif. Forestry & For. Prod. 17, 8 p.
62. Ellwood, E. L. Ecklund, B. A., and Zavarin, E. 1960. Collapse in wood: exploratory experiments in its prevention. Forest Prod. J. 10(1):8–21.
63. Ellwood, E. L., Gottstein, J. W., and Kauman, W. G. 1960. A laboratory study of the vapor drying process (in press). CSIRO Div. of Forest Products Tech. Paper.
64. Englerth, G. H. 1959. Air drying conditions for lumber in the San Juan area, Puerto Rico. Trop. For .Notes 1, 1 p.
65. Ericson, B. 1960. Latewood percentage, density and volumetric shrinkage in wood of *Picea abies* (L.) Karst. F. Virgata jacq. A comparison with *Picea abies*. Stockholm. Statens Skogsforskningsinstitut. Avdelningen for Skogsproduktion. Rapport 2, 15 p.
66. Evans, L. 1959. Principal types of kilns for drying lumber products. Lumberman 86(10):36–37.
67. Fearing, W. B. 1960. An engineering study of the solvent seasoning of tanoak, M. Sc. Thesis, University of California, Berkeley.
68. Feldt, D. 1960. Dry kiln instrument calibration. News-Digest, Wood Drying Div., FPRS (April) 2 p.
69. Field, P. 1959. Lessons learned about internally fired kilns. Lumberman 86 (10):48–49.
70. Finighan, R. 1960. Can air-drying methods be improved? CSIRO Forest Prod. Newslet. 261:1–2.
71. Finighan, R. 1959. New survey of equilibrium moisture content. CSIRO Forest Prod. Newslet. 252:1–3.
72. Finighan, R. 1958. Reducing end splitting in logs and poles; the use of end coatings. CSIRO Forest Prod. Newslet. 245, 3 p.
73. Folomin, A. I. 1955. High temperature seasoning in petrolatum. Industrial Wood Processing, No. 4.
74. Freidin, A. S. 1958. Effect of radioactive radiation on the physical and mechanical properties of wood. Trans. from Woodworking Industry USSR 7(9):13–15. CSIRO Trans. 4417.
75. Gardner, T. A. 1960. A theory of drying with air. Tappi 43(9):796–800.
76. Gavina Mujica, M. 1959. The drying of wood. [In Span.] Servicio de la Madera. 126 p.
77. Goldstein, I. S. 1959. Wood processing; inhibiting against swelling and decay. Indus. & Engin. Chem. 51(10): 1313–1317.
78. Gorling, P. 1957. Research results and trends in drying technology. Chemie-Ingenieur Technik 29(3):170–176.
79. Gottstein, J. W. 1956. An effect of peeler log heating on the subsequent shrinkage of veneers during drying. Composite Wood 3(5, 6):105–109.
80. Gottstein, J. W., and Cullity, D. M. 1955. A new type screened dryer for rotary peeled veneers. For. Prod. J. 5(5):289–294.
81. Granlund, P. 1959. Investigations of methods for drying green sawdust. Translated by L. H. Reineke from Norsk Skogindustri 12(11):411–418, Nov. 1958. U. S. For. Prod. Lab. trans. 372, 10 p.
82. Greenhood, E. R. 1958. Lumber curing process. U. S. Patent 2,834,120.
83. Guernsey, F. W. 1960. The air drying of lumber in western Canada. British Columbia Lumberman, 44(1): 40–41, 44–46.
84. Harden, R. C. 1960. The use of herbicides to control vegetation in lumber air drying and storage yards. News-Digest, Wood Drying Div., FPRS (August).
85. Hattori, M. 1959. Air-seasoning Japanese cedar poles for creosote treatment. [In Japanese]. Japan Wood Res. Soc. J. 5(3):108–110.
86. Headlee, T. M. 1960. Should I roof my lumber? U. S. Forest Service. Central States Forest Expt. Sta. Tech. paper 171, 5 p.
87. Hearmon, R. F. S., and Paton, J. M. 1958. The maximum moisture content of wood. Forestry 31(1):53–62.
88. Hedlin, C. P., and Hooper, F. C. 1959. Influence of the presence of vapor diffusion from a wetted nonadiabatic boundary upon the sensible heat transfer between a boundary wall and a gas stream. Can. J. of Chem. Engin. 37(6):208–211.
89. Hopkins, W. C. 1960. Moisture content of building structural members. For. Prod. J. 10(10):
90. Horiike, K., and Kato, S. 1959. The heat of wetting of wood. I. Hydrogen bonding and swelling of wood. J. Jap. Wood Res. Soc. 5(5):181–185.
91. Huffman, J. B. 1958. Kiln drying of Southern hardwood crossties. For. Prod. J. (6):165–172.
92. Huffman, J. B., and Post, D. M. 1960. Forced air drying of gum and oak crossties. Southern Lumberman 200 (2500):33–34, 36–37.
93. Hyler, J. E. 1959. Modern sawmilling. Parts 120–125. South. Lumberman 199 (2478–2483):31–40; 35–42; 37–45; 31–35; 33–40.
94. Ito, S. 1958. On the water suction mechanism of wood. VI. Pressure of gas locked in wood by water. J. Jap. Wood Res. Soc. 4(6):219–222.
95. Jasinskij, V. S. 1959. Investigation of the efficiency of drying wood in [the form of] planks and blanks. [in Russ.] Derev. Prom. 8(6):14–16.
96. Jayme, G., and Fengel, D. 1959. Investigation into the fine structure of bordered pit membranes in sprucewood using a moist preparative method. Holz als Roh-und Werkstoff 17 (6):226–30.
97. Johnson, P. 1958. Timber schedules for kiln drying heavy segregation redwood lumber. Research Project, California Redwood Association, San Francisco, No. 3.222120 (interim report A.)
98. Jones, B. 1960. Durability of reinforced concrete construction and repair of such structures where deterioration of concrete has taken place. News-Digest, Wood Drying Div., FPRS (March), 2 p.
99. Jorczak, K. A. 1958. An evaluation of a dielectric heating method for drying black walnut gunstock blanks. U.S. Ofc. of Tech. Serv. (PB rpt. 151301), 13 p.
100. Kaeser, L. H. 1960. Drying technique key to quality of chips. The Lumberman 87(7):80.
101. Kauman, W. G. 1960. Contribution to theory of cell collapse in wood. Aust. J. of Appl. Sci. 11(1):122–145.
102. Kauman, W. G. 1960. Collapse in some eucalypt species after treatment in inorganic salt solution. For. Prod. J. 10(9):
103. Kauman, W. G., Gottstein, J. W., and Lantican, D. 1956. The mechanical drying of "ash" eucalypt veneers. Aust. J. Appl. Sci. 7(1):69–97.
104. Kauman, W. G., Gottstein, J. W., and Lantican, D. 1956. Quality evaluation by numerical and subjective methods with application to dried veneer. Biometrics 12(2): 127–153.
105. Keer, G. A. 1959. Trends in kiln design. Wood (London) 24(12):500–502.
106. Keer, G. A. 1960. "Shipping dry"—some thoughts on Scandinavian seasoning methods. Wood (London) 25 (3):98–99.
107. Kelsey, K. E., and Christensen, G. N. 1959. The sorption of water vapour by the constituents of wood, II and III. Aust. J. Appl. Sci. 10(3):269–293.
108. Keylwerth, R., and Noack, D. 1956. Uber den Einfluss hoherer Temperaturen auf die elektrische holzfeuchtigkeitsmessung nach dem Widerstandprinzip. Holz als Roh-und Werkstoff 14(5):162–172.
109. Kishen, J., Ghosh, D. P., and Rehman, M. A. 1958. Studies in moisture content, shrinkage, swelling and intersection point of mature *Dendrocalamus strictus* (male bamboo). Indian Forest Records (New Series) Wood Seasoning 1(12):1–28.

110. Knauss, A. C., and Clarke, E. H. 1959. Seasoning and surfacing degrade in kiln-drying Douglas fir in Western Oregon. U. S. Forest Service. Pacific Northwest Forest & Range Expt. Sta. Res. Note 173, 13 p.

111. Kollmann, F. 1959. Uber die sorption von holz und ihre exakte bestimmung. [English summary] Holz als Roh–und Werkstoff 17(5):165–171.

112. Kollmann, F., and Schneider, A. 1959. Sorptionsmessungen au mit Salzen impragnierten Holzern. Holz als Roh–und Werkstoff 17(5):212–218.

113. Kollman, F., and Schneider, A. 1960. The influence of the air velocity on the kiln drying of timber in mixtures of hot air and steam. Holz als Roh-und Werkstoff 18(3):81–94.

114. Korger, M., and Viktorin, Z. 1959. The determination of drying schedules for softwood lumber. [In Czech.] Drevarsky Vyskum 4(2):223–250.

115. Kozlik, C. J. 1960. Bibliography of wood moisture relationships. Oregon Forest Products Research Center, Corvallis, 35 p.

116. Krechetov, I. V., and Tsarev, B. S. 1958. Wood drying in super heated steam. Transl. Commonw. Sci. Industr. Res. Organ. Aust. No. 3673, 8 p. Transl. by M. Slade from Derev. Prom. 4(12):9–12, 1955.

117. Kruml, J. 1959. Effect of temperature, air flow speed, and relative humidity on the moisture loss of wood in centrifugal drying. Drevarsky Vyskum 4 (2):209–221.

118. Kruml, J. 1959. Influence of centrifugal force on the moisture content of wood. [In Czech.] Drevarsky Vyskum 4(1):47–69.

119. Kumar, V. B. 1959. Application of statistical quality control methods to veneer drying. Paperi ja Puu 41(4a): 159–166.

120. Kumar, V. B. 1959. Studies on moisture determination of veneer by resistance moisture meters. Paperi ja Puu 41(4a):167–170.

121. Lambe, T. A. 1958. Dry kilns for small operations. B. C. Lumberman 42(10):46, 48.

122. Lane, P. H., and Scheffer, T. C. 1960. Water sprays protect logs from stain and decay. Forest Prod. J. 10(6):277–282.

123. Lang, A. R. G., and Mason, S. G. 1960. Tritium exchange between cellulose and water: accessibility measurements and effects of cyclic drying. Can. J. Chem. 38(3): 373–387.

124. Laursen, S. B., and Boyce, C. 1958. Preliminary calculations of costs of high frequency heating and simultaneous bending of small wood blanks. Traeindustrien 8(3): 47–49.

125. Leont'ev, N. L., Krechetov, I. V., Tsarev, B. S., and Suchova, A. V. 1958. Influence of high temperature drying schedules on the physical and mechanical properties of wood. Transl. Commonw. Sci. Industr. Res. Organ. Aust. No. 3800, 6 p. Transl. by M. Slade from Derev. Prom. 5(10):3–5, 1956.

126. Leont'ev, N. L., et al. 1957. The influence of high temperature drying on the physical and mechanical properties of Scots pine timber. Derev. Prom 6 (6):3–6.

127. Malmquist, L. 1959. Die wasserdampfsorption des holzes vom standpunkt einer neuen sorptionstheorie. Holz als Roh-und Werkstoff 17(5):171–178.

128. Malmquist, L. 1959. Drying physics—an introduction to biology. Paperi ja Puu 41(6):301–308.

129. Malmquist, L., and Meichsner, H. 1959. Investigations on the work of cross-circulation tunnel kilns. Holz als Roh-und Werkstoff 17(10):384–96.

130. Malmquist, L., and Noack, O. 1960. Studies on drying sensitive hardwoods in pure supersteamed steam at pressures less than one atmosphere. Holz als Roh-und Werkstoff 18(5):171–180.

131. McMillen, J. M. 1960. News and views of this kiln drying business. The problem: Can American elm be dried without excessive warping? U. S. Forest Prod. Lab. Rept. 1769–26.

132. McMillen, J. M. 1960. Special methods of seasoning wood: chemical seasoning. U. S. Forest Prod. Lab. Rept. 1665–5 rev., 4 p.

133. McMillen, J. M., Preston, S. B., and Kozlik, C. J. 1960. Research and practice in the U.S., Canada, and Europe . . . Status of Wood Drying—1959. For. Prod. J. 10(2):82–90.

134. Migacev, A. I. 1959. A centrifugal kiln for wood. [In Russ.] Derev. Prom. 8(4):26.

135. Mikit, E. A., and Upmanis, K. K. 1959. Kiln for rapid drying of sawn timber with superheated steam. [In Russ.] Derev. 8(8):5–6.

136. Miller, R. J. 1959. Preserving lumber in storage. For. Prod. J. 9(10):390–394.

137. Milovidov, S. G. 1958. Clamping sawn timber to prevent working during drying. [In Russ.] Derev. Prom. 7(6): 22; also translated by M. Slade, CSIRO, Australia Transl. 4516, 1959.

138. Mischenko, K. P., Talmud, S. L., and Yakimova, V. 1959. The interaction of cellulose with liquids. Vysokomolekul Soedin 1(5):662–669. Abstr. Inst. Paper Chem. 1960 31(1):

139. Mitchell, H. L., and Wahlgren, H. E. 1959. New chemical treatment curbs shrink and swell of walnut gunstocks. For. Prod. J. 9(12):437–441.

140. Nakato, K. 1958. On the cause of the anisotropic shrinkage and swelling of wood. Parts 14–15. [In Japanese with English summary] Saikyo Univ. Facul. Agr. Sci. Rept. 10:37–54.

141. Nanawawa, N. 1960. Practice of timber drying based on stress removal of wood.[In Japanese] I. Introduction and drying of lauan. II. Drying medang jonkong and beech. III. Drying of basswood. Mokuzai Kogyo (Japn. Wood Industry) 15(2):2–8; (6):8–11; (8):9–12.

142. Necesany, V. 1959. Volumetric changes of beech wood. I. The effect of basic physical properties on the cell wall saturation and the amount of swelling of wood. Drevarsky Vyskum 4(1): 13–26.

143. Necesany, V., and Morarava, E. 1959. Volumetric changes of beech wood. II. Effect of cellulose content on cell wall saturation and on the amount of volumetric swelling of wood. Drevarsky Vyskum 4(1):27–38.

144. New South Wales Forestry Commission. Div. of Wood Technology. 1959. What is seasoned timber? N.S.W. For. Comm. Div. of Wood Tech. pamphlet 7, 7 p.

145. Ngok, W. C., et al. 1959. A comparison of end coatings on keruing planks. Malayan Forester 22(2): 158–167.

146. Noack, D. 1959. Sorption of wood at elevated temperatures and water vapor pressures. Holz als Roh-und Werkstoff 17(5):205–212.

147. Noack, D., and Kleuters, W. 1960. On the determination of the moisture content of wood using radioactive isotopes (beta-rays). Holz als Roh-und Werkstoff 18(8):304.

148. Northcott, P. L., and Colbeck, H. G. M. 1959. Effect of dryer temperatures on bending strength of Douglas fir veneers. For. Prod. J. 9(9):292.

149. Nylinder, P. 1959. Some observations on the drying of round timber and damage connected with it. [In Swedish] Svenska Skogsvardsfor. Tidskr. 57 (3):459–468.

150. Oberg, J. C., and Hossfeld, R. 1960. Hydrogen bonding and swelling of wood in the dioxane-water system. For. Prod. J. 10(7):369–72.

151. Odintsov, P. N. 1958. Sorption of water vapors by the wood of spruce. [In Russ.] Latv. PSR Zinatnu Akad. Vest. 1958(2):65–69.

152. Odintsov, P. N. 1959. The swelling of lignin. Trudy Inst. Lesokhoz. Problem in Knim. Drevesiny 17:3–14.

153. Ogura, T. 1959. Studies on the mechanism of drying of wood (7). On computing the time required to dry wood by using the moisture conductivity. Japan. Gov't. Forest Expt. Sta. Bul. 117:122–163.

154. Ohnuma, K., and Saito, H. 1959. Some aspects of the effect of temperature upon shrinkage of wood. Transl. from Japan. Gov't Forest Expt. Sta. Bul. 116. Canada. Forest Prod. Lab. Trans. 134, 8 p.

155. Olson, G. 1959. Instrumentation of dry kilns. Lumberman 86(10):66.

156. Ostermeier, G. 1959. News and views of this kiln drying business. The problem: Designing stacking stalls suitable for stickering packages of lumber for lift-truck handling prior to air or kiln drying. The answer: A track system tied in with stacking stalls equipped with movable sticker-guide gates. U. S. Forest Prod. Lab. Rept. 1769–25, 2 p.

157. Page, R. H., and Carter, R. M. 1958. Variations of moisture content of air-seasoned Southern pine lumber in Georgia. For. Prod. J. 8(6):15A–18A.

158. Pankevicius, E. R. 1960. Recent studies on collapse. Australia. CSIRO Forest Prod. Newslet. 260:7–8.

159. Peck, E. C. 1960. News and views of this kiln drying business. The problem: Method of calculating shrinkage or swelling of wood with change of moisture content. U. S. Forest Prod. Lab. Rept. 1769–27, 9 p.

160. Peck, E. C. 1959. The sap or moisture in wood. U. S. Forest Prod. Lab. Rept. 768, Rev., 5 p.

161. Perkitny, T., Lawniczak, M., and Marciniak, H. 1960. The effect of steaming on the swelling pressure of wood. Transl. by J. Hardy from Holz als Roh-und Werkstoff 17(2):54–61, 1959. Australia, CSIRO transl. 4804, 16 p.

162. Peterson, R. W. 1960. The dielectric properties of wood. Can. Forest Prod. Lab. Tech. Note No. 16, 22 p.

163. Preston, R. D. 1959. The fine structure of wood with special reference to impregnation. Timber Tech., pages 503–508.

164. Rasmussen, E. F. 1960. How to reduce degrade and kiln drying costs. Furniture Design and Manufacturing 32 (3):53–54, 64.

165. Richards, D. R. 1958. High temperature drying of southern hardwoods. Circ. Ala. Agr. Exp. Sta. No. 123, 12 p.

166. Richards, E. G. 1959. Loss of weight of small-sized hardwoods due to drying. Gt. Brit. Forestry Comm. Rept. Forest Res. 1958:160–163.

167. Rietz, R. C. 1960. Kiln drying of Engelmann spruce. U. S. Forest Prod. Lab. Rept. 1944–6, Rev., 5 p.

168. Sadoh, T. 1960. The effect of moisture content and temperature upon the rate of moisture adsorption by hemicellulose. J. Jap. Wood Res. Soc. 6(2): 45–48.

169. Sadoh, T. 1960. Movement of water through hemicellulose by steady state. J. Jap. Wood. Res. Soc. 6(5):210–213.

170. Sadoh, T. 1959. The effect of pretreatment on wood hemicellulose in moisture adsorption. J. Jap. Wood Res. Soc. 5(6):218–222.

171. Sadoh, T. 1959. Studies on the relations between physical properties and chemical components of wood. On the hygroscopicities of delignified wood. Sci. Rep. Kyoto Prefect Univ. Agric. (11):114–119.

172. Salamon, M. 1960. Air circulation in dry kilns. Proc., 12th Ann. Meet. Western Dry Kiln Clubs.

173. Sallenave, P. 1959. Air drying of timber in the tropics. Bois For. Trop. (63):49–56.

174. Schniewind, A. P. 1960. On the nature of drying stresses in wood. Holzforschung (in press).

175. Sergovskij, P. S. 1959. Features of the drying of wood in liquid media. [In Russ.] Derev. Prom. 8(5):5–8; (6):7–9.

176. Serov, M. B. 1959. Method of seasoning and storing timber in piles in Leningrad timber port. M. L. Goslesbumizdat.

177. Serry, V. 1960. Cut the cost of kiln drying by improved handling. [Parts 1, 2, and 3] Timber Tech. 67(2246): 495–496; 68 (2247): 19–20; 68 (2248): 62–64.

178. Sherman, D. 1959. Twelve ways to help solve the seasoning controversy. Lumberman 86(12):32–35, 50–53.

179. Shore, D. 1960. End check prevention in redwood air drying. Proc., 12th Ann. Meet. Western Dry Kiln Clubs.

180. Siimes, F. E. 1959. On the recent development of kiln drying at Finnish sawmills and plywood factories. Transl. from Paperi ja Puu 41(4): 223–232, 1959. Australia. CSIRO unnumbered translation, 8 p.

181. Smirdin, P. M. 1958. Notes on a drying schedule for Hornbeam. Derev. Prom. 7(8):16.

182. Smith, C. 1959. Weather versus fan air drying. Nat'l Hardwood Mag. 33 (10):29.

183. Smith, C. 1959. A word of caution about fan air drying hardwoods. Nat'l Hardwood Mag. 33(9):23.

184. Smith, H. H., and Berolzheimer, C. P. 1959. Air drying of incense-cedar; tests under winter conditions in California. U. S. Forest Service. Pacific Southwest Forest & Range Expt. Sta. Tech. Paper 38, 13 p.

185. Smith, H. H., and Dittman, J. R. 1960. Effect of solid storage on the uniformity of final moisture content of kiln dried lumber. U. S. Forest Service. Pacific Southwest Forest & Range Expt. Sta. Res. Note 162.

186. Smith, H. H., and Dittman, J. R. 1960. Lumber drying and quality control of moisture content in kiln-dried lumber. For. Prod. J. 10(7):353–357.

187. Smith, W. R. 1960. Cost reduction through control of lumber yards. Furniture Manufacturer 81(2):38–40.

188. Sobczak, K. S. 1959. Influence of seasoning and plasticizing steaming upon lasting changes in mechanical and physical properties of beech wood. [In Polish with English summary] Sylwan 103(4):5–23.

189. Stamm, A. J. 1959. Wood processing: inhibiting against swelling and decay. Ind. & Eng. Chem. 51(10):1313–1317.

190. Stamm, A. J. 1960. Bound water diffusion into wood in across-the-fiber directions. For. Prod. J. 10(10):

191. Steinberg, S. E. 1956. Methods of high temperature seasoning of timber in petrolatum. Industrial Wood Processing, No. 10.

192. Stemsrud, F. 1959. The fine structure of the pit membranes of coniferous woods. II. Impregnation of spruce wood and determination of the penetration by means of radioactive isotopes. Holzforschung 13(1):16–20. [English summary]

193. Stone, J. E., and Green, H. V. 1959. Penetration and diffusion into hardwoods. Tappi 42(8).

194. Stutz, R. E. 1959. Control of brown stain in sugar pine with sodium azide. For. Prod. J. 9(12):459–463.

195. Stutz, R. E. 1960. Control of sugar pine brown stain. News-Digest. Wood Drying Div., FPRS (February).

196. Tarkow, H., and Stamm, A. J. 1960. Diffusion through the air-filled capillaries of softwoods. I. Carbon dioxide. II. Water vapor. For. Prod. J. 10(5): 247–250; (6):323–324.

197. Terazawa, S., and Kodama, S. 1957. Fundamental study on the operation of wood drying. III. A simplified estimation of drying time in kiln-drying. Transl. by A. S. Clifton from Bull. For. Exp. Sta. Meguro, Tokyo, No. 97:61–72. Transl. Commonw. Sci. Industr. Res. Organ. Aust. No. 3786. 10 p.

198. Tiemann, H. D. 1959. Shrinkage: what causes it; how can it be reduced. South. Lumberman 199(2489):147–149.

199. Tomford, W. J. 1960. Fan air system for drying lumber and wood products. News-Digest, Wood Drying Div., FPRS (November).

200. Tsutsumoto, T., and Sato, S. 1958. Veneer drying. (I) Experiments on air supply, veneer feeding method and thermal efficiency in the cross-circulation type veneer drier. (II) Experiments on air condition and veneer drying in the Coe-type roller-feed drier. Meguro, Tokyo Expt. Sta. Bul. 106:201–215; Bul. 107:33–46.

201. Ugoliev, B. N., and Steinberg, S. E. 1959. High temperature seasoning in petrolatum. Industrial Wood Processing (English language edition) 8(7): 12–14.

202. Ugoliev, B. N. 1955. A method of measuring internal stress in timber during process of air seasoning. Factory Laboratory, No. 10.

203. Ullman, A. 1959. Determination of moisture content of wood products [In Swedish] Travaruindustrien 44 (15):276–279.

204. U. S. Forest Products Laboratory. 1960. Kiln schedules and drying time. U. S. Forest Prod. Lab. Rept. 1900–5, 30 p.

205. U. S. Forest Products Laboratory. 1960. Longitudinal shrinkage of wood. U. S. Forest Prod. Lab. Rept. 1093, Rev., 10 p.

206. U. S. Forest Products Laboratory. 1960. Seasoning and preserving wood. Forest Farmer 19(7):147–149.

207. U. S. Forest Products Laboratory. 1959. List of dry-kiln companies and engineers and consultants in the United States. U. S. Forest Prod. Lab. Rept. 1031, Rev., 2 p.

208. U. S. Forest Products Laboratory. 1959. Veneer cutting and drying properties: tanoak. U. S. Forest Prod. Lab. Rept. 1766–15, 9 p.

209. Uyemura, T., and Saito, H. 1959. Measurement of moisture of wood by two high-frequency type moisture meters. Repr. Bul. Gov't For. Expt. Sta. No. 113, Tokyo, Japan.

210. Uyemura, T. 1960. Dielectrical properties of woods as indicator of the moisture. Repr. Bul. Gov't. For. Expt. Sta. No. 119, Tokyo, Japan.

211. Villiere, A. 1959. Le sechage de l'ilomba [Pycnanthus angolensis]. Bois et Forets des Trop. 68:31–38.

212. Vodoz, J. 1957. Behavior of wood during high frequency. Holz als Roh- und Werkstoff 15(8):327–340.

213. Vorreiter, L. 1958. Holztechnologisches Handbuch, Band II. 646 p.

214. Walter, F. 1958. Wood properties after seasoning. Holzindustrie, Berlin 11(1):13–17.

215. West, W. I. 1957. Index of selected journal articles pertaining to the lumber industry. Sect. 7.5 Handling, sorting, stacking and unstacking. Sec. 13. Seasoning. Oregon Cooperative Association, Corvallis, Ore. 40 p.

216. Winkel, L. 1960. Shipping weights as a guide for moisture content. Proc., 12th Ann. Meet. Western Dry Kiln Clubs.

217. Wray, C., and Mignery, A. L. 1959. Soil covers improve air drying of red oak. U. S. Forest Service. South. Forest Expt. Sta., South Forestry Note 124, 2 p.

218. Wright, G. W. 1954. The purpose and economics of predriers. Aust. Timb. J. 20(3):199–210.

219. Wright, G. W. 1956. The seasoning of the Eucalypts. FAO World Eucalypt Conference Rome. Final Report, 12 p.

220. Wright, G. W. 1957. Stacking, handling and kiln drying in Australia. Timb. J. 23 (2):51–75.

221. Wright, G. W. 1958. The seasoning of Radiata pine. Proc., 9th Forest Products Res. Conference, Australia: 56–66.

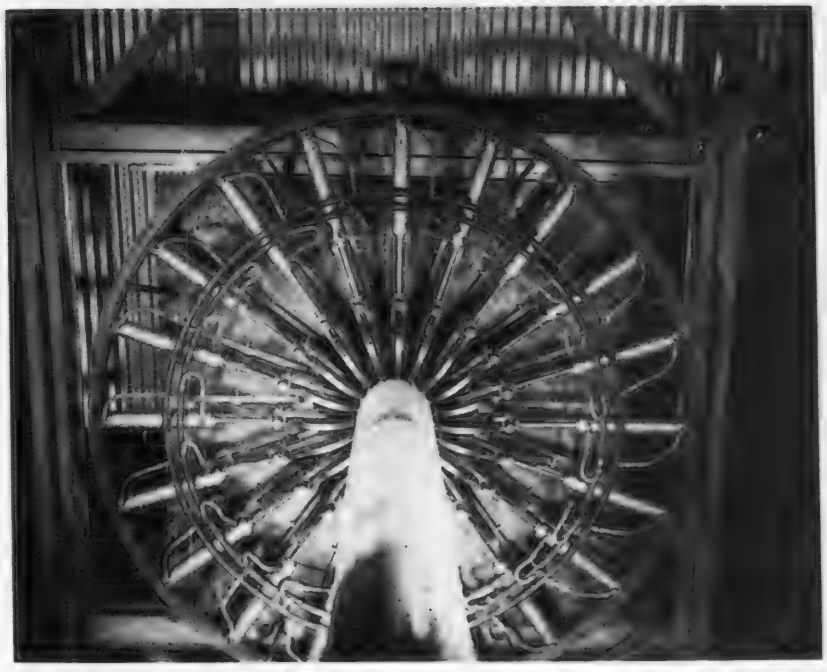
222. Wright, E., Knauss, A. C., and Lindgren, R. M. 1959. Sprinkling to prevent decay in decked western hemlock logs. U. S. Forest Service. Pacific Northwest Forest & Range Expt. Sta. Res. Note 177, 10 p.

223. Zivnuska, John. 1960. What's ahead for the lumber industry. News-Digest, Wood Drying Div., FPRS (January) 2 p.

PROGRESS IN

Wood Preservation, 1959-60[1]

H. E. TROXELL
Former Vice-Chairman, Wood Preservation Division



INCISOR FOR FULL-LENGTH TIMBERS: This machine makes a series of incisions around the surface of full-length round timbers. Result—more uniform penetration of preservative and an improved checking pattern.

Here are region-by-region accounts of: the new swing to the results specification; new methods of testing preservatives; volume of preservatives used and timber treated; wood vs. concrete for crossties; new incising machine for full-length round timbers; success of wood-pole structures; current and future research projects.

PROTECTION OF WOOD against destruction by fungi, insects, fire, and mechanical wear has challenged the practical and scientific industry of man for centuries. The lack of users' appreciation for adequately treated wood has been a definite deterrent to technological advance in certain areas. In spite of the lethargy of wood users, however, a high level of technical development has been achieved, and future requirements should be changed to keep abreast of continued research in the field.

The position of treated wood as the most useful and economical building material has been challenged by other materials probably more during the last decade than ever before in history. In the competitive sixties, the wood-preservation industry must re-examine the physical characteristics of treated wood to determine its suitability for new markets. This examination must be made with imagination as well as intelligence if treated wood is to maintain its position as the ideal low-cost construction material.

This is the sixth annual progress report covering developments achieved and literature published (a Supplemental Bibliography will be found elsewhere in this issue) in the wood-preservation field.

A comprehensive compilation of information on the protection of a variety of wood products from poles and piling to paper will have some omissions. Such omissions are unintentional. It is hoped, however, that each succeeding review has informed the membership of the progress being accomplished by the joint effort of those actively engaged in production, research, development, and utilization of preservative-treated wood.

The Author: Dr. H. E. Troxell is associate professor of wood technology at Colorado State University and vice-chairman of the Rocky Mountain Section. He holds degrees from Duke University.

At the 14th National Meeting of FPRS in Montreal, the Society's Constitution was amended by Article XI to establish as one of the 11 subject-matter divisions the Treatment and Coatings Division. This new division is a combination of the former Wood Finishing and Wood Preservation Divisions. The following officers were selected for 1960–61: Donald J. Lubeck, Chairman; Ralph H. Bescher, Co-chairman; N. Clark Hatcher, Vice-chairman—finishing; and Ira Hatfield, Vice-chairman—preservation. Tentative plans have been outlined for the 1961 program, which will center around the theme "How to Prepare and Paint Houses."

Major Advances

During the year, there were several topics that should be cited as major developments in the field of wood preservation. There seemed to be a greater concern by users of treated wood to learn more about the material. This was reflected in the interest stimulated across the country by the conferences on wood poles. These conferences have supplied information to pole users that will be helpful to the wood-preservation industry. If nothing else, they have made some pole users aware of the technical nature of the problems and the desirability of utilizing technically trained personnel in their organizations.

Result-type Specifications: There has been a great deal written recently regarding the adoption of "result-type specifications." Such specifications require that the retention of oil-type preservatives in the wood be determined by assay, as contrasted to the previously used gauge or tank readings. At least three major users of poles have

[1] More than 20 persons helped in the preparation of this report. The author especially acknowledges the assistance of J. Oscar Blew, Jr., U. S. Forest Products Laboratory; R. H. Bescher, Koppers Company, Inc., Pittsburgh, Pa.; and Ira Hatfield, Wood Treating Chemical Co., St. Louis, Mo., for reviewing the manuscript. Dr. Hatfield deserves special thanks for compiling the Supplemental Bibliography found elsewhere in this issue.

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accepted this type of specification as a standard for purchasing poles. Leutritz (6)[2] points out two major questions associated with the commercial use of the assay method for determining of retentions. They are: 1) the lack of correlation between plant gauges and assay retentions and 2) the extraction time for analysis. When proper sampling procedure is followed the data obtained by assay should provide valuable information to the consumer, to the treater, and to the wood-preserving industry. Generally, the assay method should contribute to better performance of treated wood. The shift toward the use of so-called result-type specifications has resulted from the general acceptance of assay methods and techniques for the determination of the net retention of oil-type preservatives. Full application of assay methods and techniques at the treating plants will serve as a basis for a better quality-control program.

Baechler (1) stated that the use of the result-type specification for piling has lagged behind its use for poles. This should not continue to be true because piling generally has higher initial and replacement costs than poles. At the Montreal meeting of FPRS, Hudson (5) reported the first application of the assay method as an inspection tool to insure the quality of preservative treatment for creosoted marine piling. In this evaluation, a number of different laboratories were involved in the inspection. By following set sampling procedures and the AWPA standards, it was shown that southern pine marine piling could meet retentions of 22 pounds per cubic foot. This case illustrates how producers can initiate a quality-control program that will assure the user that his product will give its expected performance.

In working with extractions of creosote from marine piling, Baechler and Roth (2) established that high retentions were essential for protection of piling. They also indicated that creosote must be from high-temperature coal carbonization and free from saturated hydrocarbons.

Test Methods for Preservative: A new method for studying the weathering of creosote was described by Smeal and Leach (10) where very small samples of 0.1 to 0.5 gram of creosote are extracted by the conventional methods from borings and sections of small test stakes. The evaporation patterns of creosote are then determined by a Stanton Thermobalance.

Incising: Puncturing the lateral surfaces of wood to secure a more uniform penetration of preservative is known as incising. Specifications for many species of wood that are difficult to penetrate require incising prior to treatment in order to obtain the minimum penetration. For a number of years, weighted hammers have been used, and more recently power machinery has been developed for this purpose. In an effort to incise full-length round timbers effectively, the Cascade Pole Company, Olympia, Washington, developed a machine (see photo) that makes a series of incisions around the surface of a round timber. The developers have stated that the machine has accomplished two purposes: 1) incising to improve the uniformity of preservative penetration, and 2) incising to improve the checking pattern. The latter statement could lead to a new concept for requiring incising of refractory species.

QUALITY CONTROL BY TOLUENE EXTRACTION: The assay method of determining whether the specified amount of preservative was retained in marine piling was first used on this 1000-foot wharf in Lake Charles, La. (See August JOURNAL, page 349.)

The U. S. Forest Products Laboratory, under the auspices of Koppers Company, developed an incising pattern and depth control for light frame sizes of wood members. The incising insures full penetration of both Douglas-fir and redwood with no effect on the strength of the lumber.

Trends in Use of Wood Preservatives

The volume of wood treated by the wood-preserving industry during 1959 reached the lowest level since 1935, according to the statistics compiled by Merrick (8). A total of 214.5 million cubic feet of wood was treated, a decrease of 18.3 million feet or almost 8 percent below 1958. The decrease was primarily caused by a 30 percent (7 million ties) decline in the number of crossties. Only 16 million crossties were treated, the smallest number since 1909 when nearly 21 million were reported.

The 1959 estimates were based on a survey of 358 wood-preserving plants (94 percent of the industry). Of all the plants reporting, 277 employ the pressure process, 55 use the non-pressure processes, and 26 are equipped to use both kinds of processes.

The amount of liquid preservatives declined 6 percent (12 million gallons) while the use of solid-type preservatives increased 18 percent (3.8 million pounds). The major decline in liquid preservatives was due to the volume of crossties treated. Creosote and creosote-coal tar solutions and creosote-petroleum solutions showed the greatest decreases, while pentachlorophenol-creosote solution tripled in use. In 1957, only 4 plants were using this preservative, now 35 plants use nearly 7.8 million gallons a year.

The use of pentachlorophenol is increasing steadily. During the last 5 years, the amount of wood treated with pentachlorophenol has doubled to about 2 million pounds. This is an increase of nearly 19 percent over 1958. Creosote still represents 69 percent of all the treated material. Pentachlorophenol and the mixture of creosote and pentachlorophenol make up 18 percent and 4 percent, respectively. All other preservatives and fire retardants were used to treat the remaining 9 percent of the material.

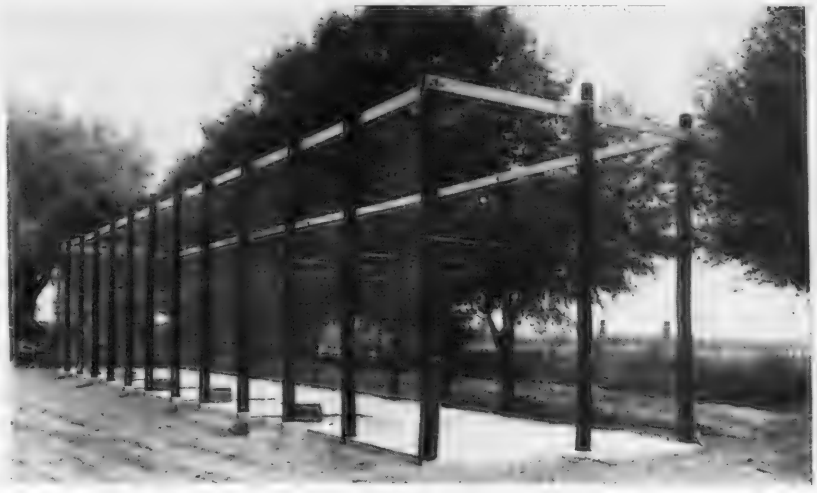
Regional Activities

North-Central: Pole-type structures are being adapted to many uses throughout the Midwest (see photo). Burpee (3) has stated that 40,000 pole buildings have been erected in the United States. Great interest was centered on the exhibit of pole buildings for the Annual Farmer's Week at Michigan State University. This trend to use more treated poles in structures should encourage use of more treated lumber in buildings. The

[2] Numbers in parentheses refer to the Literature Cited at the end of the report.

University of Minnesota has instigated a long-range program under which they will treat components of farm buildings with various types of wood preservatives, stains, and water repellents. The research program at Michigan State University includes the testing of various oil-base and water-soluble compounds as groundline treatment preservatives.

A regional Wood Utility Pole Conference was held at Iowa State University, October 19–21, 1960. Utility managers and supervisory personnel expressed interest in the processing and inspection procedures employed by the wood-preserving industry. The maintenance and inspection of poles in-service was also part of the program. More than 200 people attended the conference at Ames, Iowa.



WOOD-POLE BUILDINGS. An estimated 40,000 pole structures, such as this feed storage unit constructed of pressure-treated poles, have been erected in the United States.

South and Southeast: The School of Forestry, University of Florida, in cooperation with industry, has initiated a 2-year study to evaluate the forced-air drying of upland oak crossties. The year-round seasoning test is being set up on a commercial scale to compare the characteristics and merits of conventional air drying, covered air drying and forced-air drying. Collection of data began in June, 1960. The work is being accomplished at the Koppers Company plant in Gainesville, Florida; one railroad company and four additional wood-preserving companies are cooperating.

In March, 1960, a new challenge to the wooden crosstie industry came in the form of two, quarter-mile test installations of prestressed concrete crossties. The Seaboard Air Line Railroad installation is located 5 miles east of Tampa, Florida, and the Atlantic Coast Line Railroad installation is near Four Oakes, North Carolina. The new, prestressed concrete crossties, which were developed by the Association of American Railroads, were produced on a machine capable of turning out 1000 ties per day. Weighing about 580 pounds each, the ties were installed on 30-inch centers instead of the conventional 20-inch spacing. A service life of 50 years was predicted, and the maximum cost per tie in the foreseeable future was given at about $9.00. Some failures of the ties and fastenings have been reported within the first year. It is doubtful if the actual service will be as good as predicted.

SEASONING CHECKS. It is estimated that three-fourths of the decay in poles results from checking after treatment. Typical is this example of premature failure at the groundline resulting from a seasoning check.

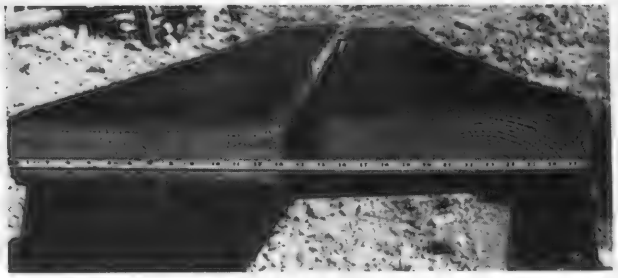
Utility pole conferences were held at Louisiana State University and the University of Florida on June 2–3 and August 23–25, respectively. These were part of the nationwide effort to increase the knowledge regarding the serviceability of wood utility poles through better programs of inspection and maintenance. Besides a thorough review of groundline treatments to combat pole decay, the problem of woodpecker damage to poles was also discussed. One Florida utility reported that in 1959 pole replacements in their system due to woodpecker attack amounted to an estimated $196,000. The utilities are investigating the use of concrete poles to meet the problem. Other conferences are being planned.

Central Rocky Mountain: Contrary to the general decline that prevailed in the production of treated wood products nationally last year, production throughout the Central Rockies remained generally stable, with a few modest increases reported in some items. This region did not experience the market drop-off in railroad ties which was reported as the dominate factor in the decline elsewhere. The tie market held steady throughout the year, which was perhaps the major reason for the shift in trends.

Interest in the groundline treatment, while not a headliner item, nevertheless continues strong, and the application of the method continued to broaden. Activity in this field revealed the need for additional information on the application and the evaluation of the method. Work in this direction was spearheaded by Colorado State University, College of Forestry. Staff members are currently analyzing the results of the first year of a study involving three preservatives and four species of wood. Analyses will center on determination of the pentachlorophenol content by the regular lime-ignition method. These results will also be compared with analyses determined by the copper-pyridine method. The study is based on treatments applied to utility poles that have been in service for some time. It differs in this respect from a study (conducted jointly by the U. S. Forest Products Laboratory, Colorado State University, and the Rocky Mountain Station) in which the groundline treatment was applied directly to freshly treated poles. The latter study was closed-out during the year, after an extension of one year.

An item of major interest and value to both the producer and user of wood products was the Wood Pole Institute that was conducted on the Colorado State University campus at Fort Collins. The program was designed to bring about a better understanding of all elements involved in the production and maintenance of utility poles and accented the role of the producer, inspector, and consumer.

Wood-treating capacity continued to increase throughout the area when two new plants went into operation in the



TESTS CONDUCTED by the Southwest Research Institute, in cooperation with the National Wood Promotion Program, showed that wood outperformed steel in fire tests.

TWISTED STEEL JOISTS after exposure to fire. In a series of three controlled tests, wood members were still structurally sound while the steel members had deflected 15 inches.

Black Hills in South Dakota. The Northwest Wood Preserving Company, a long-time landmark at Deadwood was destroyed by a forest fire last fall. This plant was rebuilt at Whitewood, South Dakota, and the firm is again in operation at somewhat increased capacity. Another plant was also installed at Deadwood, a short distance from the site of the former Northwest Preserving Company plant. The new plant is equipped to treat by either non-pressure (thermal) or the pressure method.

Further indication of expanding wood-treating facilities in the region came about with the sale of a large tract of ponderosa pine pole timber in Arizona. This timber was awarded to the firm which has been studying the feasibility of installing a modern plant for pressure-treating ponderosa pine timber. This action followed the trial run made on two carloads of ponderosa pine timber. This action followed the trial run made on two carloads of ponderosa pine poles that were taken from the sale area and processed as a check on the quality and customer reaction. The new plant will include vapor-seasoning equipment.

Inland Empire: The Intermountain Forest and Range Experiment Station reports a somewhat general decline in the wood-treating industry, but the mainline producers are maintaining their markets with superior products.

The major technical advances have occurred in the pretreatment phases of production, such as wood harvesting, yard handling, peeling, and drying. The most spectacular advance was in the development of kiln drying equipment and techniques for long poles. This technique will offer a saving in inventory costs, handling costs, and retort time. There are good indications that penetrations and retentions will be improved.

Creosote and pentachlorophenol are used in equal amounts. Other preservatives play a minor role in the area. There has been no major market change in the last 5 years. Most fence posts are either naturally durable woods or they are treated. All poles, piling, ties, and bridge timbers meet the usual treating requirements. Most millwork is given the conventional immersion treatment. Only lumber goes generally untreated. Specifications requiring preservative-treated lumber for use in the region are rare because handling on the job is difficult and no special economies can be shown for its use in the region.

At least one company has initiated a strict quality-control program to insure a treated product of high performance.

Pacific Coast: The California Forest Products Laboratory has continued its studies of isolating organic compounds from naturally durable heartwood of redwood and incense-cedar. The U. S. Forest Products Laboratory is evaluating the fungicidal properties of certain of these components. Elwood and Ecklund (4) reported on their study of bacterial attack of pine logs in storage ponds. Extensive sapwood porosity results from attack. The organisms isolated were identified as those not causing degradation to cellolosic material. Proper control of these organisms will improve the control of preservative retentions in wood susceptible to attack by these organisms.

The Northwest Wood Pole Conference was held March 21–22, 1960, at Oregon State College. This was the first regional meeting following the nationally attended meeting held at the University of Wisconsin (11). Nearly 160 managerial personnel of utilities attended. Personnel at the Oregon Forest Research Center are continuing the quality studies of Douglas-fir wood. They are investigating the variability of permeability of heartwood from different geographical areas. The Center also has a project underway to determine 1) to what moisture content poles must be dried to prevent checking subsequent to preservative treatment, 2) the effect of area soaking on checking of large pieces and on penetration of preservative, and 3) effectiveness of various drying processes. It has been found that about three-fourths of the decay in utility poles is associated with checking subsequent to the preservative treatment (see photo). The Bonneville Power Administration is cooperating with the Center. During the last 3 years, they have found incising and drying of Douglas-fir spar crossarms to be a successful solution. Drying poles to a maximum moisture content of 25 percent in the outer 2 inches may be a solution, but further study has been recommended. Krahner, studying the anatomical features related to permeability of Douglas-fir at the School of Forestry, Oregon State College, found tracheids from wood that was difficult to impregnate with preservatives to be significantly smaller than those of wood less difficult to treat. This may well be associated with variation of the fine openings in the pit membranes.

Several have reported that interest is increasing in fire-resistant treatments of Douglas-fir. Special interest is being given to plywood and other glued members. However, no figures are available on the volume of material treated. Merrick (8) shows 179 million cubic feet more treated in 1959 over 1958. The Oregon Forest Research Center is evaluating the effect that various chemicals have on the bending strength of wood. The Douglas Fir Plywood Association reports their attention is in product research where gluing is a subsequent operation to the application of the fire-retardant chemicals.

Eastern Canada: The Ottawa Laboratory, Forest Products Laboratories of Canada, is continuing investigations

of the electrical conductance properties of a series of specimens of red pine sapwood treated with greensalt O. Comparisons were made with Boliden S-25 and K-33. Accelerated service tests of red pine stakes treated with greensalt O and K-33 were installed.

Their report also indicated an intensive study was begun to evaluate the development of drying checks in crossties. This work is in cooperation with a railway company. Several treating processes were used for the crossties with the primary objective of coating the crossties after they were placed in service.

Service tests of eastern hemlock treated by a non-pressure proprietary preservative to a retention of 0.6 pound per tie were concluded. Untreated crossties lasted on the average of 6.25 years, whereas the treated ties lasted 15.2 years.

Three new commercial pressure treating plants employing water-borne salts were established: one at Maple Creek, Saskatchewan; the second at Christopher Lake, Saskatchewan; and the third one at Kenora, Ontario.

Western Canada: The Vancouver Laboratory, Forest Products Laboratories of Canada, carried out research to improve the penetration and retention of preservative in round western hemlock for use as poles and piling, and of sawn mountain-type Douglas-fir for railway ties and construction timbers. One of the phases of treatment investigated was the steaming and vacuum conditioning process in order to evaluate its effect. Another closely related problem under investigation is the permeability of Douglas-fir. They found some specimens of this species very permeable, while others are impermeable. A study of capillarity is being conducted to segregate the permeable and impermeable specimens. The durability of wood treated with preservatives is assessed by test in public utility installations and also by stakes in test plots. The stakes contain various preservatives and have penetrations and retentions of different amounts. Further study is being done to determine the effect that incising of seasoned wood has on the strength properties of poles.

Puerto Rico: The Tropical Research Center, United States Forest Service, reports a comprehensive project where 30 sepcies of fence posts were treated by double diffusion. Twenty replications were made of each species and the posts were set at two locations for the determination of service life.

A commercial plant using Wolman salts continues to treat to capacity. There is a trend for the treatment by Wolman salts of termite-susceptible furniture and millwork for protection against dry-wood termites. In the past, it was the practice to make most furniture from termite resistant mahogany.

In San Juan Harbor, a cooperative piling project (9) was undertaken by the American Wood Preservers' Institute, the U. S. Forest Products Laboratory, and the U. S. Coast Guard. One 7-pile dolphin was pulled and turned over to the U. S. Forest Products Laboratory for tests and analysis. Replacement piles were furnished with precisely known amounts of creosote-coal tar solution. Performance records will be maintained of this full-scale service test.

Association Activities

The American Wood-Preservers' Association revised 11 standards and added one new standard to its Manual of Recommended Practices. The new standard established requirements for preservative treatment by pressure processes of structural glued laminated members and laminations before gluing. Species included are Coast region Douglas-fir, southern yellow pine and oak.

The revised standards include two new water borne preservatives and changes in retention values for some species. Several modifications were made to prepare for the use of results-type specifications.

T. M. Gurd, Tmbers, Ltd., New Westminister, B. C., Canada, was elected AWPA president at the annual meeting in April. Immediate past-president is G. Q. Lumsden, Bell Telephone Laboratories, Murray Hill, New Jersey.

The American Wood Preservers Institute during the past year, under the guidance of Executive Director C. Miles Burpee, intensified its activities to encourage greater use of pressure-treated wood. The AWPI played a prominent part in developing Division 15 of Guide Specifications on Carpentry and Millwork, a section of "Guide Specifications for Architects Working on Public Housing Administration Housing."

On October 1, 1959, the American Institute of Timber Construction adopted a treating standard for structural wood members. The timber construction industry indicated its concern with the compatability of adhesives with various preservative treatments. Possibly further research in this area will remove some of the problems. AITC is working with Highway Sign Bridges in the use of treated structural lumber. Ward Mayer, Founder and Chairman of the Board of Timber Structures, Inc., was re-elected president of the Institute.

The Cooling Tower Institute elected E. C. Smith, Hudson Engineering Corporation, president for 1960. This group is dedicated to advancement in technology and performance of water-conservation equipment. During their tenth year of service, 12 specifications and technical bulletins are available to manufacturers of cooling towers. One of the specifications (CTI Bulletin WMS-112, June, 1959) covers the minimum retention and penetration requirements for redwood, Douglas-fir, and southern yellow pine.

The National Woodwork Manufacturers Association has been interested in special activities in the field of wood preservation for 33 years. The history and development of wood preservation for millwork was reviewed by Lance (7). Currently, the NWMA supports three special research projects. The first study deals with methods for evaluating water-repellent preservative solutions. This work was begun in 1956 under a cooperative agreement with the U. S. Forest Products Laboratory. Both laboratory tests and outdoor exposure tests are being conducted. In the laboratory tests, seven test methods were used: 1) swellograph; 2) flowing water; 3) swellometer; 4) water spray; 5) cupping; and 6) weight gain at 30 to 80 percent relative humidity. In the outdoor exposure tests, two types of wood specimens were used: right-angle specimens and window sash. The laboratory tests were completed in 1958 and summarized in Report TP No. 81, December, 1958 by the U. S. Forest Products Laboratory. The outdoor tests are still in progress and will continue for several years. A progress report TP-97 was made in June, 1960; however, final results correlating the laboratory and service tests have not been determined.

The second study concerns the problem of over-absorption of treating solution by ponderosa pine shop lumber used in manufacture of millwork. The Western Pine Association has led this work. The NWMA, collaborating with WPA and the U. S. Forest Products Laboratory, will continue this project for several years.

A third study relates to paint discoloration. This project was launched early in 1960 by the National Paint, Varnish and Lacquer Association. J. H. Sampson, White Pine Sash Company of Spokane, Washington, is president of the NWMA for this year.

The Railway Tie Association publishes monthly the Cross Tie Bulletin, which publishes articles of interest to producers, treaters and users of railroad ties. D. B. Frampton, Jr., D. B. Frampton and Company, is president and the organization has six standing committees: 1) Checking and splitting

of cross ties; 2) timber conservation; 3) manufacturing practices; 4) national affairs (legislation); 5) mechanical handling, and 6) safety. A new committee is being added to promote crossties. This group is of extreme importance to the future of the preservative treaters of crossties if markets are to be maintained and not replaced by prestressed concrete.

The Rocky Mountain Pole and Treating Association, with membership composed of commercial producers and processors of western species of poles treated by the thermal process, is continuing its sponsorship of the annual pole-production survey in the northern Rocky Mountain Region. This survey has been conducted annually since 1947 in cooperation with the U. S. Forest Service. Reports are obtainable from Intermountain Forest & Range Experiment Station, Ogden, Utah. D. R. Meigs, B. J. Carney & Company, Spokane, Washington is president of the Association.

Bibliography

The Selected Bibliography was compiled by Ira Hatfield, Wood Treating Chemicals Co., St. Louis, Mo. Other members of the committee who submitted citations to Dr. Hatfield were: Roy Baechler, U. S. Forest Products Laboratory, Madison, Wis; E. A. Behr, Michigan State University, Department of Forest Products, East Lansing, Mich.; Ralph Bescher, Koppers Co., Inc., Pittsburgh, Pa.; A. H. Bishop, New York State College, School of Forestry, Syracuse, N. Y.; J. Oscar Blew, U. S. Forest Products Laboratory, Madison, Wis.. C. Miles Burpee, American Wood Preservatives Institute, 111 West Washington Street, Chicago, Ill.; Reginald Colley, Bernuth, Lembcke Co., Inc., 420 Lexington Ave., New York, N.Y.; R. D. Graham, Forest Research Center, Corvallis, Ore.; John Leutrits, Jr., Bell Telephone Laboratories, Murray Hill, N. J.; L. A. Mueller, Rocky Mountain Forest & Range Experiment Station, Ft. Collins, Col.; G. E. Olson, Dow Chemical Co., Midland, Mich.; Howard Olson, Sonford Products, Minneapolis, Minn.; A. P. Richards, William F. Clapp Laboratories, Duxbury, Mass.; H. E. Troxell, Jr.; Colorado A & M College, School of Forestry, Ft. Collins, Colorado; C. S. Walters, Forest Utilization Research, 219 Mumford Hall, Urbana, Illinois.

The Committee wants it noted that the references basically were selected to cover the period from June 1, 1959 to May 31, 1960.

Literature Cited

1. Baechler, R. H., 1959. Determining preservative retention in piling by the assay of borings. U. S. For. Prod. Lab. Report No. 2172. 10 pp.
2. ---------- and H. G. Roth, 1960. Extraction of creosote from marine piles of variable age and condition. Proc. Amer. Wood-Pres. Assoc. Vol. 56:12–19.
3. Burpee, C. M., 1960. The economic advantages of modern treated wood. Symposium on Wood for Railroad Uses. 17 p. (Mimeographed)
4. Ellwood, E. L. and B. A. Ecklund, 1959. Bacterial attack on pine logs in pond storage. For. Prod. Jour., IX, No. 9:283–292.
5. Hudson, M. S., 1960. Quality control by toluene extraction for the procurement of creosoted marine piling. For. Prod. Jour. Vol. X, No. 7:349–352.
6. Leutritz, J., Jr., 1960. Pretreatment determination of moisture and density to facilitate retention assays of oil-type preservatives. Proc. Amer. Wood-Pres. Assoc. Vol. 56:20–26.
7. Lance, O. C., 1958. History and development of wood preservation for millwork. For. Prod. Jour. VIII, No. 12. 61-A-65-A.
8. Merrick, G. D., 1960. Wood preservation statistics 1959. Proc. Amer. Wood-Pres. Assoc. Vol. 56:249–283.
9. Roche, J. N., 1960. Cooperative piling project—U. S. Coast Guard Base, San Juan Harbor, Puerto Rico, Proc. Amer. Wood-Pres. Assoc. Vol. 56:205–208.
10. Smeal, T. W. and S. W. Leach, 1960. A new method for studying the weathering of creosote. For. Prod. Jour. Vol. X, No. 10:509–512.
11. Walters, C. S., 1960. Problems and practices in wood preservation, 1958–59. For. Prod. Jour. Vol. X, No. 2: 73–81.

Selected Bibliography

Continental United States

Allen, D. G. and J. A. Rudinsky. 1959. Effectiveness of thiodan, sevin and lindane on insects attacking freshly cut Douglas-fir logs. Jour. Econom. Ent. 52 (3): 482–484.

American Wood Preservers Institute (AWPI.) 1959. How to design and build marinas. 16 page, illus. report, published by the Institute, Chicago, Ill.

AWPI. 1959. Timeber piles test-loaded to 150 tons. Wood Preserv. News 37 (7): 13–18.

AWPI. 1959. Timber flumes cut taxpayer cost. Wood Preserv. News 37 (7): 20.

AWPI. 1959. Noncombustible wood. Wood Preserv. News 37 (8): 4.

AWPI. 1959. Field treating pile cut-offs. Wood Preserv. News 37 (8): 14.

AWPI. 1959. Wood posts are strongest, Australian tests agree. Wood Preserv. News 37 (8): 20–21.

AWPI. 1959. Pressure treated posts give lowest cost fences. Wood Preserv. News 37 (8): 23.

AWPI. 1959. Good lumber can be made better. Wood Preserv. News 37 (9): 4.

AWPI. 1959. How piling costs were cut 46%. Wood Preserv. News 37 (9): 7–10.

AWPI. 1959. Highway uses of treated lumber. Wood Preserv. News 37 (9): 18.

AWPI. 1959. How to buy good quality. Wood Preserv. News 37 (10): 4.

AWPI. 1959. How to build a pole-type warehouse. Wood Preserv. News 37 (10): 12–14.

AWPI. 1959. Home owners need protection. Wood Preserv. News 37 (11): 4.

AWPI. 1959. Another load test shows 3rd way to cut piling costs. Wood Preserv. News 37 (11): 5–7, 10.

AWPI. 1959. Umbrella lumber shed trussed by cables. Wood Preserv. News 37 (11): 18, 20.

AWPI. 1959. New wide contour wood seats will put Giant fans at ease. Wood Preserv. News 37 (11): 22–23.

AWPI. 1959. News in pictures. Wood Preserv. News 37 (11): 24.

AWPI. 1959. Part I—Special report on home building. Which house has hidden values? Wood Preserv. News 37 (11): 12–14, 16.

AWPI. 1959. Part II—Special report on home building. Protected lumber delivers distinguished service. Wood Preserv. News 37 (12): 6–9, 20.

AWPI. 1960. Part III—Special report on home building. How to get "health insurance" for your home. Wood Preserv. News 38 (1): 14–17.

AWPI. 1959. From barns to business. Wood Preserv. News 37 (12): 4.

AWPI. 1960. How to build homes that will outlive the mortgage (Third edition) Amer. Wood Pres. Institute, Chicago, Ill.

AWPI. 1960. Bridges for secondary roads. Wood Preserv. News 38 (1): 4.

AWPI. 1960. Hay keepers save labor in storing, curing, feeding hay. Wood Preserv. News 38 (1): 20.

AWPI. 1960. Are brush treatments effective? Wood Preserv. News 38 (2): 4.

AWPI. 1960. Crash tests prove best designs for median barriers. Wood Preserv. News 38 (2): 6–7.

AWPI. 1960. News in pictures. Wood Preserv. News 38 (2): 14.

AWPI. 1960. Concrete will not stop termites. Wood Preserv. News 38 (3): 4.

AWPI. 1960. Underground power cables —do they justify the trouble and expense Wood Preserv. News 38 (3): 10, 12.

AWPI. 1960. Low-cost insurance. Wood Perserv. News 38 (4): 4.

AWPI. 1960. 56 years of consistent foundation practice on the Illinois Central. Wood Preserv. News 38 (5): 18–19.

AWPI. 1960. New use of treated wood in pacakage-swimming pool. Wood Preserv. News 38 (5): 24–25.

AWPI. 1960. Annual fire loss $1.4 billion. Wood Preserv. News 38 (6): 4.

AWPI. 1960. What price long life? Wood Preserv. News 38 (6): 6–7, 20.

AWPI. 1960. Pennsylvania Railroad floors 9,100 cars with pressure treated wood. Wood Preserv. News 38 (6): 10, 22.

AWPI. 1960. Hydro-electric power from stave pipe. Wood Preserv. News 38 (6): 12, 14.

AWPI. 1960. U.S.D.A. features pole building design in cotton warehouse report. Wood Preserv. News 38 (6): 16–18.

Anderson, A. B., E. L. Ellwood, B. Zavarin and R. W. Erickson. 1960. Influence of extractives on seasoning stain of redwood lumber. Forest Prod. J. X (4), 212–218.

Anderson, A. B., and W. B. Fearing. 1960. Solvent seasoning of tanoak. Forest Prod. J. X (5): 234–238.

Anonymous. 1957. Pressure-treated wood posts in modern highway construction. 44 page illus. mimeog. compilation. Pub. by Canadian Institute of Timber Construction. Ottawa, Canada.

Anon. 1959. Pole framing: it saved $2,500 in foundation costs on this house. American Builder 81 (8): 82–86.

Anon. 1959. Gotham OK'S wood, others follow suit. New York Lumber Trade J. 127 (8): 18, 38–39.

Anon. 1960. How to fabricate and erect panelized farm buildings. 16 page brochure, published by West Coast Lumberman's Association, Portland, Oregon.

Anon. 1960. Admiral successfully fumigates floating drydocks for termites. Pest Control 28 (3): 60, 62.

Anon. 1960. Treated Douglas-fir used in 6,000 foot pipe line. Forest Prod. J. X (4): 18–A.

Anon. 1960. IP offers pre-fab structures. Western Conservation Jour. 17 (3): 42–43.

Anon. 1960. Treated wood finds many new uses. Western Conservation Journ. 17 (3): 50–51.

Baechler, R. H. 1959. Improving wood's durability through chemical modification. Forest Prod. J. IX (5): 166–171.

————. 1959. Determining preservative retention in piling by the assay of borings. USDA, Forest Prod. Lab. Report No. 2172, Madison, Wisc.

————. E. Conway and H. G. Roth. 1959. Treating hardwood posts by the double-diffusion method. Forest Prod. J. IX (7): 216–220.

————. and H. G. Roth. 1960. Extraction of creosote from marine piles of variable age and condition. AWPA Proc. 56: 12–17.

Barnwell, J. B. 1959. Timber pier designed to reduce marine borer damage. Wood Preserv. News 37 (10): 20–21.

Bates, D. W. 1959. How to select and treat poles and posts. Hoard's Dairyman 104 (18): 936, 948.

Becker, W. B. 1959. Further tests with BHC emulsion sprays to keep boring insects out of pine logs in Massacusetts. Jour. Econom. Ent. 52 (1): 173–174.

Behr, E. H. 1960. When PCOs should use fungicides to treat buildings. Pest Control 28 (2): 9–10, 12, 14, 16, 19–20.

Blew, J. O. 1959. Preservatives for wood pallets. USDA, Forest Prod. Lab. Report No. 2166. Madison, Wisc.

————. 1960. Comparison of wood preservatives in stake tests (1960 Progress Report) USDA, Forest Prod. Lab. Report No. 1761. Madison, Wisc.

———— and J. W. Kulp. 1959. Service records on treated and untretaed fence posts. USDA, Forest Prod. Lab. Report No. 2005. Madison, Wisc.

———— and ————. 1960. Comparison of wood preservatives in Mississippi post study. (1960 Progress Report). Forest Prod. Lab. Report No. 1757. Madison, Wisc.

Bois, P. J. 1959. Wood moisture content in homes. Seasonal variations in the Southeast. Forest Prod. J. IX (11): 427-430.

Bready, J. K. 1960. Nutritional studies on subterranean termites. Pest Control 28: (6): 43–44.

Brentlinger, P. D. 1959. Termite control investigation. Proc. Amer. Railway Eng. Assoc. 60: 131–142.

————. 1960. A treated car lumber program for the Pennsylvania Railroad. AWPA Proc. 56: 79–84.

———— et. al. 1959. Report of Committee 17—Wood preservation. Amer. Railway Eng. Assoc. Bulletin 61 (554): 415–424.

————. et. al. 1959. Report of Committee 17—Wood preservation. Proc. Amer. Railway Eng. Assoc. 60: 341–377.

Campbell, R. N. 1959. Fungus sap-stains of hardwoods. Southern Lumberman 199 (2489): 115–120.

———— and J. W. Clark, 1960. Decay resistance of baldcypress heartwood. Forest Prod. J. X (5): 250–253.

Chandler, L. 1959. Home building speed-up helps make horntail a pest in structural timbers. Pest Control 27 (6): 46–53.

Collister, L. C. 1960. Fire retardant treatments on the Santa Fe. Proc. Amer. Railway Eng. Assoc. 61: 1098–1106.

Conners, W. M. and G. Bramhall. 1960. Boiling and impregnation in the preservation of round western hemlock. Proc. AWPA 56:36–43.

Daniels, B. E. et. al. 1959. Effect of a proprietary fire-inhibiting substance on the flammability of treated southern yellow pine. Amer. Railway Eng. Assoc. Bulletin. 61 (552): 209–241.

————. et al. 1960. Methods of fireproofing wood bridges and trestles, including fire-retardant paints. Proc. Amer. Railway Eng. Assoc. 61: 590–609.

Davies, W. E. I. 1959. All this for $3.88 per square foot. Wood Preserv. News 37 (7): 8–10.

Diller, J. D. and E. J. Koch. 1959. Weight losses of 40 wood species exposed to *Poria incrassata* and *Merulius lacrymans*. Forest Prod. J. IX (9): 298–302.

Dost, W. A. 1959. Attempts to modify the weathering of redwood. Forest Prod. J. IX (3): 18–A—20–A.

Drisco, R. and H. Hochman. 1959. The use of chromatography in the analysis of creosote. A.S.T.M., STP, 275.

Drubel, R. B. and W. E. F. Rupprecht. 1960. Latex-fire-retardant intumescent coatings. Forest Prod. J. X (3): 152–155.

Dudley, A. 1959. Good posts are key to fence life. Western Dairy Jour. 15 (11): 57, 60–62.

Duncan, C. G. 1960. Soft rot in wood, and toxicity studies on causal fungi. AWPA Proc. 56: 27–34.

————. 1960. Wood-attacking capacities and physiology of soft-rot fungi. USDA, Forest Prod. Lab. 70 page illus. Report 2173. Madison, Wisc.

Duvall, V. L. and L. B. Whitaker. 1959. Now! A cattle repellent for pines. Forest and People 9 (4): 32–33, 46.

Ebeling, W. and R. E. Wagner. 1959. Two newer weapons for drywood termite control and prevention. Pest Control 27 (2): 40, 42, 44–46.

Edison Electric Institute. 1959. Methods for inspection of standing poles in overhead lines. Publication No. 59–74. 20 page report of Transmission and Distribution Committee. Edison Elect. Instit. New York, N. Y.

Ellwood, E. L. and B. A. Ecklund. 1959. Bacterial attack of pine logs in pond storage. Forest Prod. J IX (9): 283–292.

Erickson, G. L. 1960. Recent developments on creosote. AWPA Proc. 56: 138–155.

Erickson, H. D. 1960. The effects of storage conditions and time upon permeability of green sapwood. AWPA Proc. 56: 156–165.

Esyln, W. E. 1959. Radiographical determination of decay in living trees by means of the Thulium x-ray unit. Forest Science 5 (1): 37–47.

Estrada, N. S. 1960. Exterior finishes for wood . . . Some of the problems involved. Forest Prod. J. IX (6): 28–A—31–A.

Ferguson, E. R. 1960. Wood treated with penta (PCP) can damage pine nursery seedlings. Tree Plant. Notes No. 38. U. S. Forest Serv., Washington, D. C.

Ferris, W. H. 1959. Penta-treated poles endure. Electrical World 151 (12): 41.

Flynn, T. J. 1960. Beach homes secured against storms. Wood Preserv. News 38 (4): 10–12.

Forbes, L. M. 1959. Fire-retardant pole-type warehouse. Wood Preserv. News 37 (12): 16–18.

————. 1960. Introducing the "compact car" of home building. Wood Preserv. News 38 (5): 8–10, 12.

————. 1960. This is a 'hidden value' home. Wood Preserv. News 38 (3): 6–9.

Giles, D. T. 1959. How to protect a shore road. Wood Preserv. News 37 (9): 14–16

————. 1960. Low-cost, pole-type hangars. Wood Preserv. News 38 (2): 10–12.

————. 1960. Washington expands sewage plant. Wood Preserv. News 38 (4): 14, 16, 18.

Gill, T. G. 1959. Improving the service life of cross ties—10-year summary report. Amer. Railway Eng. Assoc. Bulletin 61 (551): 13–50. This summary has the following parts:

A—Cross-tie deterioration (pp. 14–18).
B—Deterioration of wood in contact with iron (pp. 19–20).
C—Combined seasoning and treating (pp. 21–28).
D—Design of cross ties (pp. 28–31).
E—Evaluation of tie coatings (pp. 32–36).
F—Strengthening the tieplate area (pp. 37–41).
G—The effect of ultrasonics on improving the treatability of wood (pp. 42–45).
H—Non-destructive testing of wood (pp. 45–47).
I—Dimensional stabilization of wood (pp. 47–50).

Goldstein, I. S., W. A. Dreher, E. B. Jeroski, J. F. Nielson, W. J. Oberly and J. W. Weaver. 1959. Wood processing —Inhibiting against swelling and decay. Ind. Eng. Chem. 51 (10): 1313–1317.

Gooch, R. M., D. L. Kenaga and H. M. Tobey. 1959. Fire retardants for wood treated with oil-type preservatives. Forest Prod. J. IX (10): 325–329.

Graham, R. D. and D. J. Miller. 1958. Service life of treated and untreated fence posts. 3 page mimeographed "Supplement to Progress Report. 11", Forest Prod. Res. Center, Corvallis, Oregon.

———— and E. Wright. 1959. Stronger spray cuts pole rot. Electrical World 152 (4): 60.

Hamilton, L. S. 1959. Will you buy treated wood? Hoard's Dairyman 104 (20): 1038, 1049.

Hartford, F. D. 1960. Timber pile bridges cost less. Wood Preserv. News 38 (1): 9–12, 27.

Hartman, C. F. 1960. The past and future of fire retardant lumber. AWPA Proc. 56: 107–113.

Hatfield, I. 1959. Research needed on major problems in wood preservation. Forest Prod. J. IX (5): 26–A—29–A.

———— S. S. Sakornbut, E. F. Kaeable and W. W. Paris. 1960. Studies of pentachlorophenol motility in relation to solvent translocation. Part. II—Pentachlorophenol distribution in pressure treated pole stubs and cross-arms in service. AWPA Proc. 56: 166–174.

Hochman, H. 1959. Deterioration of wood by marine boring organisms. Budocks Tech. Digest 99: 7–13.

Hunt, R. W. 1959. Wood preservatives as deterrents to drywood termites in the Southwest. Jour. Econom. Ent. 52 (6): 1211–1212.

Kenaga, D. L. and E. B. Cowling. 1959. Effect of gamma radiation on Ponderosa pine: hygroscopicity, swelling, and decay susceptibility. Forest Prod. J. IX (3): 112–116.

Kennedy, R. W. 1958. Strength deterioration in wood decayed to small weight losses. Forest Prod. J. VIII (10): 308–314.

Kinney, E. E. 1959. Correct embedment for pole structures. Wood Preserv. News 37 (10): 6–9.

Kozlik, C. J. 1959. Bibliography of special seasoning methods. Oregon Forest Prod. Res. Center, Corvallis, Oregon.

————. 1960. Bibliography of moisture-relationships. Oregon Forest Prod. Res. Center, 35 page mimeograph. (365 citations), Corvallis, Oregon.
Kring, J. S. 1959. Chemical debarking and treating hardwood fence posts. Tenn. Farm and Home Sci. Prog. Rpt. 29: 6–7.
Laughnan, D. F. 1959. Effects of wood on durability of finishes. Forest Prod. J. IX (1): 19–A—21–A.
Lee, P. G. M. 1959. Termite control in Malaya. Pest Control 27 (2): 34, 36.
Lemire, E. H. 1959. When to sell the home building market pre-construction treatment. Pest Control 27 (11): 36, 38.
Leutritz, J. 1960. Pretreatment determination of moisture and density to facilitate retention assay of oil-type preservatives. AWPA Proc. 56: 20–24.
Lund, A. E. 1959. Douglas-fir plywood: its treated and natural resistance to termites. Forest Prod. J. IX (7): 220–223.
————. 1959. Subterranean termites and fungi mutualism or environmental association. Forest Prod. J. IX (9): 320–321.
————. 1960. Termites and wood destroying fungi. Pest Control 28 (2): 26–28.
————. 1960. Termites and their attack on sound wood. Pest Control 28 (6): 40, 42, 44.
———— and M. A. Taras. 1959. Kiln drying chemically treated scarlet oak and white oak lumber. Forest Prod. J. IX (11): 398–403.
Lund, H. O. 1959. Tests of the ability of *Reticulitermes flavipes* (Kollar) to build tubes over pine wood chemically treated for rot control. Jour. Econom. Ent. 52 (3): 533–534.
Lyon, R. L. 1959. Toxicity of several residual-type insecticides to selected Western bark beetles. Jour. Econom. Ent. 52 (2): 323–327.
Magee, G. M. 1960. Advantages and disadvantages of prestressed concrete relative to treated wood ties. Cross Tie Bulletin 41 (1): 30–35.
Mann, R. H. 1959. 55 year-old piles used in renovation. Wood Preserv. News 37 (8): 16, 18, 20.
————. 1960. Consolidated Edison selects low-cost timber pile foundations. Wood Preserv. News 38 (4): 6, 8.
Meloling, R. A. 1959. Architects design farm sheds! Wood Preserv. News 37 (8): 22, 27.
————. 1960. Treated timber piles required for Malibu Beach homes. Wood Preserv. News 38 (1): 18.
Merrick, G. D. 1960. Wood preservation statistics—1959. AWPA Proc. 56: 251–283.
Miller, R. J. 1959. Preserving lumber in storage. Forest Prod. J. IX (10): 390–394.
Murphey, W. K. 1959. Nature has its own fence post preservative. Ohio Farm and Home Res. 44 (320): page?
————. 1960. Some factors influencing cold soaking of fence posts. Ohio Agric. Exp. Sta. Res. Circ. 82. 8 pages. Wooster, Ohio.
Olafson, P. and J. Leutritz. 1959. The toxicity of creosote and creosote-pentachlorophenol mixtures to cattle. AWPA Proc. 55: 54–57.
Panek, E. 1960. Results of groundline treatments one year after application to Western red cedar poles. AWPA Proc. 56: 225–233.
Parcher, J. V. and R. E. Means. 1959. Soil conditions and termite control. Part one: Characteristics of soils. Pest Control 27 (2): 29–30, 32.
———— and ————. 1959. Soil conditions and termite control. Part two: Chemical application, structural safeguards. Pest Control 27 (3): 57–58, 60.
Powell, J. M. 1960. A Southern builder talks to termite operators. Pest Control 28 (2): 32, 42, 44.
Putman, R. B. 1960. You can build profits with pressure-treated lumber. The Lumberman 87 (2): 46, 48.
Ray, D. L. 1960. Marine boring and fouling organisms. 536 page book. Univ. Washington Press, Seattle, Wash.
———— and D. E. Stuntz. 1959. Possible relation between marine fungi and limnoria attack on submerged wood. Science 129 (3341): 93–94.
Rehm, D. M. 1960. Beautiful low-cost vacation cabins built on timber pole A-frames. Wood Preserv. News 38 (3): 16–18.
————. 1960. Glulam rib beams frame modern church. Wood Preserv. News 38 (5): 14, 16.
Roche, J. N. 1960. Cooperative piling project—U. S. Coast Guard Base, San Juan Harbor, Puerto Rico. AWPA Proc. 56: 205–207.
Roff, J. W. and H. Shen. 1959. Loss in stiffness evaluates decay resistance of wood treated with copper napthenate. Forest Prod. J. IX (8): 262–265.
St. George, R. A., H. R. Johnston and R. J. Kowal. 1960. Subterranean termites, their prevention and control in buildings. USDA, Home and Garden Bulletin No. 64. 30 pages (22 figures). U. S. Govt. Printing Office, Supt. of Documents, Washington 25, D. C.
Schipper, I. A. and R. Anders. 1959. A preliminary report—toxicology of wood preservatives to swine. No. Dak. Farm Research 21 (1): 8–11.
Schneider, F. E. et al. 1960. Report of Committee 7—Wood bridges and trestles. Amer. Railway Eng. Assoc. Bulletin. 61 (555): 585–609.
Scott, K. G. 1960. South California TO's views of FHA preconstruction termite preventives. Pest Control 28 (1): 35–36, 38.
Silverborg, S. B. 1959. Rate of decay in northern hardwoods following artificial inoculation with some common heart-rot fungi. Forest Science 5 (3): 223–228.
Smith, D. C. 1960. 99.998% Sound! Transmission and Distribution 12 (4): 12–13.
Snodgrass, E. R. 1959. Benefits of standardization of treatment mixtures and boring for the tie industry. Cross Tie Bulletin 40 (11): 65–67.
Speaker, J. 1959. Portable unit applies preservatives to wooden pole checks and cracks. Electrical South 39 (10): 77.
Stacey, W. A. 1959. 54 years of foundation practice in the Kansas Cities. Wood Preserv. News 37 (8): 8–10, 12.
Stamm, A. J. 1959. Toward new and better means of dimensionally stabilizing wood. Forest Prod. J. IX (3): 107–110.
————. 1959. Effect of polyethylene glycol on the dimensional stability of wood. Forest Prod. J. IX (10): 375–381.
———— and R. H. Baechler. 1960. Decay resistance and dimensional stability of five modified woods. Forest Prod. J. X (1): 22–26.
Stutz, R. E. 1959. Control of brown stain in sugar pine with sodium azide. Forest Prod. J. IX (12): 459–463.
Taras, M. A. and M. Hudson. 1959. Seasoning and preservation treatment of hickory crossties. Hickory Task Force and Southeastern Forest Expt. Sta. Hickory Task Force Report No. 8. 24 page illus. Asheville. N. C.
Tarkow, H. 1959. General summary of the FPL wood stabilization seminar. Forest Prod. J. IX (3): 110–111.
Tierney, F. P. 1960. Utility pole controls. AWPA Proc. 56: 86–91.
Turrie, W. J. 1959. Our experience with horntails in Milwaukee. Pest Control 27 (7): 52.
Vaughan, J. A. 1959. Who buys ASA specification-poles? Electric Light & Power 37 (22): 107–109, 202–203.
Verrall, A. F. 1959. Control of wood decay in buildings. Pest Control 27 (10): 9, 11–13, 16, 18, 71–72, 74.
————. 1960. Preventing moisture problems in wood siding in the South. Forest Prod. J. X (3): 148–151.
Walters, C. S. 1960. Problems and practices in wood preservation, 1958–9. Forest Prod. J. X (2): 73–81.
———— and W. L. Meek. 1959. Assaying penta-treated wood by means of diazo compounds. Forest Prod. J. IX (8): 251–257.
Weaver, J. W., E. B. Jeroski, and I. S. Goldstein. 1959. Dyes for preserving wood. Forest Prod. J. IX (10): 372–374.
Whitmore, R. A. 1959. Increasing sawmill profits by air-drying lumber. So. Lumberman 198 (2470): 30–31, 34.
Wright, C. G. 1959. Beetles found in yellow pine floor joists of buildings in North Carolina. Jour. Econom. Ent. 52 (3): 452.
Wright, E., A. C. Knauss and R. M. Lindgren. 1959. Sprinkling to prevent decay in decked western hemlock (*Tsuga heterophylia*) logs. U. S. Forest Serv. Pacific Northwest Forest and Range Expt. Sta. Res. Note 177. 10 pages.

Other Than Continental United States

Anonymous, 1959. Control of wood destroying organisms (animals and plants) by HF. Holz-Zbl. 85 (132): 1769.
Anon. 1959. Treatments and uses of wood and wood based materials. Wood Ind., Tokyo. 14(11): 2–48.
Anon. 1959. Wood preservation (A supplement with eight authors). WOOD 24 (6): 232–250.
Anon. 1959. Timber proves of highway value. British Col. Lumberman 43 (12): 59.
Anon. 1960. South Africa's forest industry. WOOD 25 (2): 61–63.
Anon. 1960. British wood preservatives in Australia. Timber Tech. 68 (2248): 75–76.
Anon. 1960. Moisture retardanta for timber. WOOD 25 (3): 100.
Armstrong, F. H. and J. G. Savory. 1959. The influence of fungal decay on the properties of timber. Effect of progressive decay by the soft rot fungus, *Chaetomium globosum*, on the strength of beech. Holzforschung 13(3): 84–89.
Barnacle, J. E. 1959. A pole test against *Mastotermes darwiniensis*. C.S.I.R.O. Forest Prod. Newsletter. No. 254: 1–3.
————. 1960. A marine borer test in Australian waters. C.S.I.R.O. Forest Prod. Newsletter. No. 262: 1–3.
Bavendamm, W. 1959. Protection of wood poles by the injection process. Cobra (Wood Treatment) Ltd., London, N.W. 3. Report No. 6: 13 pages.
———— and W. Schneider. 1959. Investigations on the practical application of the brush and trough method by using bifluorides for the impregnation of timber. Holz Roh-u. Werkstoff 17 (7): 284–291.
Bayley, C. H. and G. R. F. Rose. 1960. Metal-organic complexes formed during the treatment of wood with metal salts. Nature 185 (4709): 313–314.
Becker, G. 1959. Contribution to the knowledge of the efficiency of boron compounds against wood-destroying insects and fungi. Holz Roh-u. Werkstoff 17 (12): 484–488.

———— and A. Buro. 1959. Absorption and depth of penetration with spraying of insecticides for the control of the house longhorn beetle. Holz Roh-u. Werkstoff 17 (7): 268–280.

Belford, D. S. and C. D. Cook. 1959. The distribution of salts in timber pressure treated with a water-borne preservative. WOOD 24 (10): 411–412.

————. R. D. Preston and C. D. Cook. 1959. The impregnation of timber by water-borne preservatives. I. General survey. J. Appl. Chem. 9 (3): 192–200.

Bletchly, J. D. 1959. The influence of soft rot on the susceptibility of beach to attack by the common furniture beetle. Record British Wood Pres. Assoc. pp. 5–15.

————. 1960. Studying the eggs of *Lyctus brunneus*. Timber Tech. 68 (2247): 29, 31.

———— and R. H. Farmer. 1959. Some investigations in the susceptibility of Corsican and Scots pine and European oak to attack by the common furniture beetle (*Anobium punctatum*). Jour. Inst. Wood Science. No. 3: 2–20.

Boocock, D. 1959. Behavior and treatment of bark beetles. Timber Tech. 67 (2240): 261–263.

————. 1959. The behaviour and treatment of pine shoot beetles. Timber Tech. 67 (2243): 367–369.

————. 1959. The behaviour and treatment of ambrosia beetles (Part 1). Timber Tech. 67 (2245): 453–456.
(Part 2—continued, Jan. 1960). Timber Tech. 68 (2247): 33–35.

————. 1960. The behaviour and treatment of the oak pinhole borer. Timber Tech. 68 (2248): 73–74.

————. 1960.. The harmful effect of fungi on both trees and timber. Timber Tech. 68 (2249): 111, 113, 115.

————. 1960. The development, spread and classification of fungi. Timber Tech. 68 (2250): 153–155.

————. 1960. Information on the nature and cause of sapstain. Timber Tech. 68 (2251): 190–192.

Boulton, E. H. B. 1959. Some forest pests. Record British Wood Pres. Assoc. pp. 163–172.

Bramhall, G. 1960. Protection of wood structures in British Columbia waters. Canadian For. Prod. Lab., Vancouver Branch. Bull. No. 126.

Bruce, W. E. 1959. Timber for sea and river defence work. WOOD 24 (6): 252–254.

————. 1960. Wood preservation. The Dock & Harbour Authority 41 (475): 22–24.

————. 1960. Fire retardants. The Dock & Harbour Authority 41 (475): 33–34.

————. 1960. The care of timber in buildings. House & Garden (April—pp. 82–83)

————. 1960. Preservative treatment of timber for agricultural and horticultural uses. Country Gentlemen's Estate Magazine (May—pp. 177–180).

Buro, A. and E. A. Buro. 1959. Studies on the permeability of pine wood. Holz Roh–u. Werkstoff 17 (12): 461–473.

Carr, D. R. 1959. Boron as a wood preservative. Record British Wood Pres. Assoc. pp. 105–122.

————. 1959. The effectiveness of boron as a wood preservative. Timber Tech. 67 (2242): 335–338; 67 (2243): 371, 373–375.

Chisholm, T. H. and J. W. Suggitt. 1959. Woodpole groundline preservatives. Ontario Hydro Res. News 11 (2): 25–28, 35–36.

Colley, R. H. 1959. An interpretation of the trends in the producing of treated wood and in the use of wood preservatives in the United States, 1953–1958. Record British Wood Pres. Assoc. pp. 174–180.

————. 1959 Ein Verfahren zur Prüfung von Holzschutzmitteln gegen Meerwasserschadinge. Deut. Gesellschaft für Holzforschung 46: 24–26.

Cox, H. A. 1959. The treatment of timber damaged by rots or bettles. Estates Gazette (Aug.).

————. 1959. Timber rot in buildings. Part I in Maintenance & Equipment News for Churches. Sept. pp 12–14; Part 2 in Dec. pp. 13–17.

————. 1960. Beetles which damage timbers. Part 1 in Maintenance & Equipment News for Churches; March, and Part 2 in June issue.

Da Costa, E. W. B. 1959. Control of blue stain. C.S.I.R.O. Forest Prod. Newsletter. No. 258: 1–2

Dale, F. A. 1960. First commercial high-pressure plant starts production. C.S.I.R.O. Forest Prod. Newsletter. No. 265: 1–2.

Dorn, H. 1959. The behaviour of wood in fire, with or without protection treatment. Holz-Abl. 85 (123): 1641–1642.

Eades, H. W. and J. W. Roff. 1960. Relative decay resistance of Western hemlock and Douglas fir plywood and effect of weathering. Timber of Canada 21 (2): 70–71, 73, 75, 82, 85.

Etheridge, D. E. and L. A. Morin. 1959. A modification of the wood block decay test for studying imperfect fungi. Division of Forestry, Department of Agriculture, Canda. Bi-monthly Progress Report 15 (4): 1.

Findlay, W. P. K. 1959. Choosing the right wood preservative. (Part 1) Timber Tech. 67 (2236): 75–78.

————. 1959. Choosing a preservative. 2. Tar oil preservatives. Timber Tech. 67 (2237): 123, 125, 127.

————. 1959. Choosing a preservative. 3. Waterborne preservatives. Timber Tech. 67 (2238): 167, 169, 171–172.

————. 1959. Choosing a preservative. 4. Solvent type preservatives and their application. Timber Tech. 67 (2239): 215, 217, 219, 221.

————. 1959. Deterioration of wood by fungi and its prevention by chemical treatments. Chem. and Indus. 22: 662–665.

————. 1960. Preservative treatment of timber in buildings. Timber Tech. 68 (2250): 147, 149–152.

————. 1960. Boron compounds for the preservation of timber against fungi and insects. Pest Technology 2 (6): 124–127.

————. 1960. The preservative treatment of horticultural timbers. Timbers 68: 229, 231–232.

Forest Product Research News. 1960. Fungi aid research. British Columbia Lumbermen 44 (2): 52.

————. 1959. Wood Piling. British. Columbia Lumberman 43 (12): 54.

Forest Prod. Lab. Reports. 1960. Wood moisture relationship. Canada Lumberman 80 (1): 43.

Furze, J. E. 1959. The chemistry and engineering of timber preservation. South African Indus. Chem. 13 (4): 80–86.

Gersonde, M. 1959. Beeintrachtigung eines Randschutzes von Bauholz durch Regen. Holz Roh-u. Werkstoff 17: 10–18.

Geweke, H. 1959. The Boucherie steeping plus pressure-sleeve/vacuum-cap method. Holz Roh-u. Werkstoff 17 (10): 381-383.

Glaser, T., E. Tavocinski and J. Bauze. Investigations on interactions between the fungus *Discula brunneo-tingens* H. Meyer and most important fungi accompanying it in the process of coffee-brown discoloration of pine sawlogs. Poland Inst. Tech. Drewna 6 (2): 45–58. (English summary).

Goto, T., M. Araki, and S. Kadita. 1958. Studies on the dimensional stabilization of wood. 1. On β-naphthylamine-impregnated wood. J. Japan Wood Research Soc. 4 (4): 131–133.

Gurd, J. M. 1959. The American Wood-Preservers' Association and some recent developemnts in the wood preserving industry. Record British Wood Pres. Assoc. pp. 73–84.

Hanson, A. G. and D. Wilson. 1959. A survey of the wood preservation industry in Australia; 1957–1958. Australian Timber Jour. 25(3): 11, 13.

Harris, E. C. and J. M. Taylor. 1960. Powder-post beetles for test purposes. Timber Tech. 68 (2251): 193–195, 197.

Harrison, D. L. 1959. The toxicity of wood preservatives to stock. Part 1: Pentachlorophenol; Part 2: Coal tar creosote. New Zealand Veterinary Jour. 7: 89–98.

———— and C. G. W. Mason. 1959. The toxicity of wood preservation to stock. Part 3: The fixed arsenates. New Zealand Veterinary Jour. 7: 120–125.

Hickin, N. E. 1959. An introduction to the study of wood decay. Pest Technology 1 (12): 270–273.

Hickson, B., D. Boocock, W. E. Bruce, H. A. Cox, S. Hygate, E. H. Nevard and S. A. Richardson. 1959. Wood preservation applications and developments. WOOD 24 (6): 237–254.

Hof, T. and J. G. A. Luijten. 1959. Organotin compounds as wood preservatives. Timber Tech. 67 (2236): 83–84.

Hume, C. 1960. The use of timber in administration buildings. The Dock & Harbour Authority. 41 (475): 31–33.

Jaap, J. H. 1960. Timber construction for wide-span transit and storage buildings. The Dock & Harbour Authority. 41 (475): 17–22.

Jehle, R. 1959. Barking machines. Forstarchiv. 30 (11): 227–228.

Jonas, G–Z. 1959. Investigations on the impregnability of *Aspidosperma quebrachoblanco* preservatives and processes. Holz Roh-u. Werkstoff 17: 352–357.

Kalnin, M. M. 1959. Long-term investigations on the efficiency of preservatives. Lesnaya Promyshlennost. 6: 20–21.

Kampf, W. D. 1959. Zur Profung von Holzschutzmitteln gegen die marinen Hozbohrasseln der Gattung *Limnoria* im Laboratorium. Anz. Schadlingskde. 32: 38–40.

Keating, W. G. 1959. Comments on specifications relating to quality and preservative treatment of telephone poles. Australian Timber J. 25 (8): 81–82, 84, 87, 89–90.

Kollman, F. 1959. The economic importance of modern wood preservatives. Holz Roh. u. Werkstoff 17 (7): 261–267.

————. 1959. Die eigenschaftsanderungen von Grubenholz nach Schulzsalzimpragnierung. Forschungsber. Landes Nordrh.—Westf. No. 698. Kiln u. Opladen: Westdt. Verl., 94 pp.

————, E. Schmidt, R. Teichgraber and E. Bour. 1959. Comparative investigations on German and Swedish pinewood used for poles. Holz Roh–u. Werkstoff 17: 474–483.

————, and A. Schneider. 1959. Sorption measurements on wood impregnated with salts. Holz Roh–u. Werkstoff 17 (5): 171–178.

Korting, A. 1960. Decrease in weight with wood infested by house longhorn beetle as criterion for the degree of destruction. Holz Roh–u. Werkstoff 18: 167–?.

Kunzelmann, E. 1959. Die Resistenz von Holzfaser– und Holzspanplatten gegen holzzerstorende Pilze und Feuer. Mit-

teilungen der Gesellschaft fur Holzforschung 46: 33–39.
Lawson, D. I. 1959. Wood and fire research. Jour. Inst. Wood Science 4: 3–13.
Liese, W. and H. von Pechmann. 1959. Investigations on the influence of soft-rot fungi on wood strength. Forswiss Cbl. 78 (9/10): 271–9.
Lignum, S. 1959. Bekanntgabe untersuchter und bewerteter Holzschutzmittel und Spezialanstriche fur Holz. Publication des produits homologues pour la preservation du biis. Liste No. 1., 3 pp.
Marian J. E. and A. Wissing. 1960. The chemical and mechanical deterioration of wood in contact with iron. Svensk Papperstidning.
Part 1. Mechanical deterioration. 63 (3): 47–57.
Part 2. Chemical decomposition. 63 (4): 98–106.
Part 3. Effect of some wood preservatives. 63 (5): 130–132.
Part 4. Prevention of deterioration. 63 (6): 174–183.
McCarthy, D. F. 1959. The resistance to leaching in sodium carbonate-sodium bicharbonate buffer of some water-borne preservatives in sapwood blocks of *Pinus radiata* and *Eucalyptus regnans*. Div. of For. Prod., C.S.I.R.O. Melbourne. Report No. 5. 10 pp.
McEwan, R. J. 1959. Creosote for pole preservation. Nyasaland Farmer and Forester. 4 (4): 8–9.
McHugh, J. J. 1960. The measurement of timber defects. Timber Tech. 68 (2250): 141–144.
McNeil, D. 1959. Further studies on the composition of wood preserving creosote. Record British Wood Pres. Assoc. pp. 136–150.
McQuire, A. J. 1959. Limitations imposed by some water-borne preservatives on the soil black test method for timber. Nature 184 (4696): 1430.
————. 1959. Stain and mould control or boron treated timber. New Zealand Timber J. and Wood Prod. Rev. 5 (10): 65.
Milnes, W. F. 1959. Canada's first osmose pressure treating plant. Canada Lumberman 79 (8): 23–25.
Narayauamurti, D., S. S. Ghosh, N. Prasad and G. M. Berma. 1960. Note on an ancient buried wood dredged out from the bed of the River Ganga near Makameh, Bihar. Holz. Roh-u. Werkstoff 18: 59–63.
Nevard, E. H. 1959. Preservation of plywood. WOOD 24 (6): 239–241.
Nishimoto, K. and Y. Inouye. 1959. Methods for testing the effectiveness of preservatives. 1. On the process for weathering of preservatives with weather meter. Wood Res., Kyoto Univ., Japan. 20: 55–74.
Ohnuma, K. 1959. Method for calculation of temperature in wood during the heating period. Forestry Experimental Station, Meguro, Tokyo, Bull. No. 111. pp. 133–142.
Oliver, A. C. 1959. Use of X-rays in the detection of *Teredo* in wood. Jour. Inst. Wood Sci. 3: 47–52.
————. and R. P. Woods. 1959. Resistance of timber to marine borers. Timber Tech. 67 (2240): 265–267.
Pannell, J. P. M. 1960. Timber in harbour and dock engineering. The Dock & Harbour Authority. 41 (475): 13–16.
Perkitny, T. and T. Greczynski. 1959. Investigations on the impregnation of wood with water-soluble salt solutions by the Rueping process and its economical redrying. Holz Roh–u. Werkstoff 17 (7): 292–296.
Preston, R. D. 1959. The fine structure of wood with special reference to timber impregnation. Record British Wood Pres. Assoc. pp. 31–57.
————. 1959. The fine structure of wood with reference to impregnation. Timber Tech. 67 (2245): 459, 461–464.
————. 1959. The fine structure of wood with reference to impregnation. Timber Tech. 67 (2246): 503–508.
Puri, Y. N., R. P. Sharma, and B. K. Bakshi. 1959. Toxic resistance of *Poria monticola* to copper and zinc nutrient medium. J. Sci. Industr. Res. India. 18C (8): 149–152.
Purushotham, A. 1959. A short note on the 'Vecu' wood preservative. Jour. Timber Dryers' and Preservers Assoc. of India. 5 (2): 20–23.
————, J. N. Pande and A. P. Kureel. 1959. A preliminary note on the treatment of timber by the hot and cold process in an open tank wherein provision has been made for the application of vacuum and low pneumatic pressure. Jour. Timber Dryers' and Preservers Assoc. of India 5 (3): 10.
————, V. D. Sebastian, and P. N. Grover. 1959. A preliminary note on the protection of timber logs from splitting and deterioration by insects, termites, marine borers and fungi for short periods during transit and storages. Jour. Timber Dryers' and Preservers Assoc. of India 5 (4): 15–19.
————, and M. C. Tewari. 1959. Testing of wood preservatives. Jour. Timber Dryers' and Preservers Assoc. of India 5 (4): 2–7.
Rennerfelt, E. 1959. Laboratory testing of wood preservatives. Svenska Skogsvforen. Tidskr. 57 (3): 469–474.
Richardson, H. 1960. The fire endurance of timber structures. The Dock & Harbour Authority 41 (475): 29–31.
Richardson, S. A. 1959. Nature's pattern for the destruction of timber. Pest Technology 1 (6): 152–154.
Roldan, E. F. 1958. Hyphal penetration of the staining fungus *Ceratostomella Sp.* in Rattan and its significance in controlling stain. The Philippine Journal of Science 87 (1): 37–45.
————, and E. M. Mendoza. 1959. Wood decay in house and other similar structures and its control. Lumberman. (Manila). 5 (2): 8–10, 41.
Rubes, V. 1959. The preservation of refractory woods. Timber Tech. 67 (2235): 37–41.
Rudman, P. 1959. Factors affecting the durability of teak. C.S.I.R.O. Forest Prod. Newsletter No. 253: 1–2.
————. 1959. Decay resistance. Holzborschung 13 (4): 112–115.
Santoro, F. H. 1959. Fases lunares e insectos que apolillan maderas. Folletos Tecnicos No. 1. Direc. de Inv. Forest. (citiation not complete).
Sargent, A. 1959. Timber preservation using penta-chlorophenol. Australian Timber Jour. 25 (9): 86–87.
Schmidt, H. 1960. A termite test with sawdust of different wood species. Holz Roh–u. Werkstoff 18 (2): 59–63.
Segura, J. B. 1959. Preservative treatment of round timber. Lumberman. (Manila) 5 (2): 5–7.
Shaltyko, G. E., L. I. Pshedetskaya and K. K. Sergeenkova. 1959. The use of sodium thiosulfate in fungicidal wood imprenating solutions. Zhur. Priklad Khim. 32 (7): 629–632 (Russian).
Shibamoto, T. and Y. Inoue. 1959. Studies on water-borne wood preservatives. VIII. Relation between the hygroscopicity and fixation phenomena of treated wood. Jour. of Japanese Wood Research Soc. 5 (3): 86–92.
Smith, D. N. and R. Cockcroft. 1959. The loss and movement of creosote in pressure-treated timber during service; examination of two creosoted posts after 30 years. WOOD 24 (6): 232–236.
————, and D. T. Purslow. 1960. Preservative treatment of Pine (Pinus) sapwood by non-pressure methods. Timber Tech. 68 (2248): 67, 69–71, 76.
Stabnikov, V. N. 1959. New methods of timber protection. Derev. Prom. 8 (10): 7–8. (Russian)
Tewari, M. C. 1959. Testing of wood preservatives. III. Jour. Timber Dryers' and Preservers Assoc. of India 5 (1): 17–27.
————, and A. Purushotham. 1959. Testing of wood preservatives. V. Jour. Timber Dryers' and Preservers Association of India 5 (4): 11–15.
Theden, G. and C. Buchmann. 1959. On the problem of house longhorn beetle in lime treated wood. Holz Roh-u. Werkstoff 17: 281–284.
Thomas, A. M. and M. G. White. 1959. The sterilization of insect infested wood with high frequency heating. WOOD 24 (10): 407–410.
Part 2—Tests with stray-field heating. WOOD 24 (11): 449–451.
Part 3—Test results. WOOD 24 (12): 487–488.
Tibbett, D. C. 1958. Fire retardants for wood. 8 pages, Building Note No. 33, 8 pp. Div. of Building Research, National Research Council, Ottawa, Canada.
Tinto, J. C. 1959. Penetrabilidad de maderas cultivadas. (mimeografo). Trab. presentado a la Primera Reunion Latinoamericana de Tecnologia de la Madera. Bs. As. (marzo-abril).
————. 1959. Impregnacion de postes para uso rural. Experiencias realizadas en la Agentina con maderas de especies forestales cultivadas. 33 pp. Trab. presentado a la Primera Reunion Latinoamericana de Tecnologia de la Madera Bs. As. (marzo–abril).
————. 1959. Postes de eucaliptos para alambrados (mimeografo) 7 pp. Trab. presentado a la Primera Reunion Latinoamericana de Tecnologia de la Madera. Bs. As. (marzo–abril).
————. 1959. El approvechamiento de algunas especies indigenas de los bosques andino-patagonicos para postes impregnados. Trab. presentado a las 2as. Jornadas Argentinas de Parques Nacionales. (2–6 de Noviembre).
Tottenham, H. 1960. Timber shell roofs for storage buildings and transit sheds. The Dock & Harbour Authority 41 (475): 34–37.
Turney, H. 1959. New incisor for better pressure treating at bell pole. Canada Lumberman 79 (7): 30–32.
Walters, N. E. M. 1960. Decay in timber. C.S.I.R.O. Forest Prod. Newsletter No. 260: 1–4.
Wazny, J. Studies on the effect of *Merulius lacrymans* (Wulf.) Fr. and *Coniophora cerebella* Pers. on the mechanical properties of wood. Holz Roh-u Werkstoff 16(8): (pages & year?)
White, M. G. 1959. The status of the house longhorn beetle. Timber Tech. 67 (2244): 406–409.
Wilson, W. J. 1959. The detection of preservatives in wood with pyrocatechol violet. Analytica Chimica Acta. (Amsterdam) 21 (2): 150–154.
————. 1959. New spot tests for treated lumber. New Zealand Timber Jour. 6 (1): 69.
Woods, R. P. 1960. Timbers for marine construction. The Dock & Harbour Authority 41 (475): 25–29.
Yonekawa, S. 1959. Ammonium copper pentachlorophenate, a new water-soluble preservative. Transl. For. Prod. Lab. Can. No. 213. (limited distribution)

Glues and Gluing Processes[1]

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AS IN OTHER RECENT ANNUAL REVIEWS on glues and gluing processes, attention is being directed to certain specific developments that have been reported during the past year without any effort being made to include an exhaustive review of all of the literature, either in the technical periodicals or in the more popular trade magazines, on this broad subject.

As in last year's review, contributions were solicited and received from a number of foreign correspondents of prominence in the glues and gluing field as well as from representatives of the different sections of the Society in the United States.[1] Some of the trends indicated and some of the products and processes mentioned have not necessarily been publicly announced, and information has been obtained from various sources.

Because of the recent reorganization of the Subject Matter Divisions of the Society, the new Division of Glues and Gluing Processes includes plywood formerly covered in a separate division. The tentative sections in the new division include adhesives, plywood, glued laminated products, sandwich construction, assemblies, and end- and edge-gluing.

Symposium on Adhesives

A symposium on adhesives for the wood industry was conducted at the U. S. Forest Products Laboratory in Madison on January 13–15, 1960 (1).[2] A group of approximately 120 researchers and executives from the wood industry, present adhesive manufacturers for the wood industry, manufacturers of adhesives for other applications, and from the major chemical manufacturers attended this symposium. Executives of the wood industry discussed the present major glued wood products and the use of current adhesives with their limitations. Other speakers covered potential new glued wood products which will be important in the next few years as means of improved utilization of our available timber resources. These included paper-overlaid lumber, components of wood for building construction, sandwich panel constructions, and shop and field fabrication problems. Adhesive manufacturers then discussed some of the possibilities of developing better adhesives, and chemical manufacturers added some suggestions on possible contributions from new basic chemicals and polymers to the formulation of better adhesives for wood in the future.

LAMINATED TIMBER BEAMS in Denver, Col., synagogue. Beams meet at peak on a hexagon bearing block, which is also of laminated wood. (Courtesy Best Wood Products Co.)

No revolutionary gains were made in 1960, but many products and processes were modified and improved. Potential of gluing in broad utilization programs is being recognized as never before. One encouraging sign—the expanding interest of major chemical suppliers.

The review committee in summarizing the discussions at the symposium offered a list of recommendations as follows:

1) That the wood industry make a continued and concerted effort to define more clearly the requirements for glues in specific glued wood products.

2) That adhesive manufacturers continue their efforts to familiarize themselves with the changing requirements of the wood industry. They are urged to evaluate new raw materials, such as new polymers and catalyst systems, new technology developed from other adhesive applications in meeting requirements for application to wood.

3) That manufacturers of processing equipment be encouraged to take a more active interest in the development of improved equipment for all phases of the gluing process.

4) That there should be closer cooperation between the wood product manufacturer, the glue manufacturer, and the equipment manufacturer in contributing to research and development programs needed to produce new and improved wood products.

5) That continued attention be directed toward the development of new and improved glued products of wood and of combinations of wood with other materials in the interest of economic utilization of our forest resources.

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[2] Numbers in parentheses indicate references cited in the bibliography.

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6) That greater attention be directed towards research on the requirements and performance of binders in particle board and other molded wood products. Better understanding is needed of relationships between processing variables and bond properties.

7) That fundamental research be undertaken to determine more precisely the nature of the interface between glue and wood surfaces at various species of modified woods. More research is also needed to understand the interaction of glue and wood as related to the chemical structure of glue components and the nature of wood substance. The rheological properties of the glues, themselves, and of the final glue line should be studied further for better understanding of joint formation and behavior. Fundamental work should be undertaken to understand the nature of stresses in glued joints under different conditions of joint geometry and under various types of loading.

8) That more research be undertaken to understand the fundamental nature of the deterioration of glue joints and of glued wood products in service. Every effort should be made to develop reliable short-term test procedures to ascertain the probable permanence of glues in joints on a performance basis, and to insure that these tests correlate adequately with actual service experience.

9) That research be continued to develop improved quality-control tests for glued wood products.

10) That greater effort be made to develop improved specifications for glues and glued-wood products so that the quality may be properly safeguarded without excessive and unrealistic performance requirements.

11) That continued attention be given to the exchange of current views and research findings in the field of new adhesives and glued wood products.

This continuing effort for research workers, producers, and other technical personnel to consider current problems in wood adhesives and to plan together on solutions for correcting them is encouraging. One important development in recent years has been the establishment of a Technical Committee of the West Coast Adhesive Manufacturers, made up essentially of representatives of the major adhesive manufacturers on the West Coast. This group has been meeting regularly (2). One of the largest projects undertaken has been the development of an "Improved Method for Evaluation of Resin Exterior-Type Adhesives" (2). Other subjects covered by the committee have been reports on direct-fired veneer dryers and their effect on plywood performance and on how the plywood industry can improve control on the glue bond quality. Such groups can work effectively with government agencies and other industry groups in developing more effective standards for glues and glued products.

Some Statistics

It has been reported (1) that in the past 10 years the production of softwood plywood in the United States has increased more than fourfold and that in 1959 reached 7.7 billion square feet on 3/8-inch rough basis. An unofficial report on Canadian plywood for 1959 indicates production of 1,532,177,000 square feet of all plywood on a 1/4-inch basis. In 1958, the production of hardwood plywood produced in the United States was 792,079,000 square feet of surface measure (1). In the same year, approximately 1,703,413,000 square feet of hardwood plywood on the same basis was consumed in the United States. The difference in these two figures represents the effect of foreign imports of hardwood plywood.

The glued laminated wood industry is said to use in excess of 100 million board feet of lumber per year and approximately 5 million pounds of glue on a dry basis. These figures are expected to increase (1).

Some figures on plywood production in Australia in 1958–59 indicated plywood production as follows:

	Cubic feet
Waterproof	513,764
Commercial	2,814,748
Sliced fancy	320,492
Case	41,680

Phenol-Resin Glues in Plywood

During the last year or so there have apparently been some interesting changes in thinking on the use of phenolic-resin glues, particularly in the softwood plywood industry of the West Coast. There was a definite trend towards the use of larger amounts of extended phenolic-resin glues for the interior types of this plywood. This may be due in part to a more rigorous interior-type test requirement in Commercial Standards CS 45–55 reported last year, and also to the increased use of Douglas-fir plywood for sheathing in home building where somewhat greater water and moisture resistance may be needed than for strictly interior or short-time uses. The possibilities of the softwood industry going directly to an all-exterior type production have also been discussed rather seriously. The Douglas-fir plywood industry in western Canada has been producing only exterior plywood until recently when one plant began to produce an interior type.

The continued interest in the greater use of phenolic resins in plywood has apparently sparked the building of additional facilities for manufacturing phenol on the West Coast. One company announced (3) the selection of a site in Washington for a 36-million-pound-per-year phenol plant scheduled to be completed in mid-1961. Another unit by the same company was contemplated in western Canada. A second chemical manufacturer was reported to have started engineering work on a 4- to 5-million-dollar phenol plant in Washington with an initial output of around 30 million pounds per year and was talking about a second plant in British Columbia with a capacity of 24 million pounds per year. The major reason for this expansion was considered to be the increasing plywood market. In 1954, production of phenolic resins for plywood was quoted as 35 million pounds. By 1959, this production was 60 million pounds—an increase of 70 percent.

During the past year or so a great deal of attention has been given to special phenolic-resin glues for plywood, particularly those in film form, to simplify or entirely reduce the spreading of liquid glues. There are a number of reasons why the film glues are desirable for gluing Douglas-fir veneers. For example, their use permits greater control of glue spread at economical levels on veneer of increasingly greater surface roughness. Their use also eliminates waste of veneers that go through the conventional glue spreaders and don't pick up satisfactory glue spread and are therefore discarded. These film glues are considered to be very promising in more complete automation of the plywood-making process, a subject which has been receiving increasing attention in the softwood-plywood industry for several years.

The first phenolic-film glue on the West Coast in recent years was a conventional dry film, quite similar to that produced for a number of years in the East and used in special aircraft and other hardwood plywood (4). This film glue is intended to be cut into sheets and slipped between the veneer during the assembly process, thus completely eliminating any mixing, handling, or spreading of conventional liquid glues.

A special version of this is the wet-web film glue process (5) which involves essentially the spreading of sheets of special thin but strong paper through special double-roll glue spreaders to apply rather conventional liquid phenol-resin glues as a carefully controlled film. The paper coated with wet glues is then immediately inserted into the assembly of veneers and is then ready for pressing. Some ad-

vantages cited for the wet-web process (5) are pronounced savings of adhesives and veneer, substantial savings in production labor, the ability of adhesive suppliers to provide new resin and adhesive systems that glue faster and cure more efficiently, and simplified quality control. Apparently the glue user has a wider choice of adhesives with the wet-web process than with the dry-film process. The wet-web process is also being considered for protein-type glues. The utilization of these film-type adhesives must be coupled with special development in plant equipment for a more continuous layup system (6). The economics of the automation process in plywood manufacturing have been considered by several (7).

The dry phenol-resin film glue has been used for specialty gluing such as secondary bonding of hardwood veneer faces to Douglas-fir plywood. In one process, the fir plywood core and a hardwood overlay veneer are assembled with a sheet of film glue using a polyvinyl-acetate emulsion as a temporary adhesive to prevent the veneer, film, and plywood from getting out of alinement during handling before pressing. Staple guns could be used in place of the polyvinyl emulsion. This film glue eliminates damage to panels from glue slopping, bleed-through, the blister or blows.

This dry-film glue is also being investigated for bonding aluminum foils and sheets on the surface and between internal plies of plywood. It is reported to produce very satisfactory bonds between such aluminum surfaces.

The dry-film glue is also being used to bond medium-density phenolic-paper overlay sheets to softwood plywood.

A considerable renewed interest in the film-type phenolic adhesives has been reported in Canada also during the past year, both by the plywood industry and the furniture industry. At least one small plywood plant has marketed standard, exterior-type, sheathing-grade plywood made with this type of adhesive. The interest in the furniture industry has been from the point of view of eliminating the moisture added with wet mixes and to try to decrease the perennial problem of surface checking in highly finished furniture panels due to shrinkage stresses. There are no reports to date on the success of this approach or if it has shown advantages over conventional wet glues for this purpose.

The use of a phenolic-resin dry-film glue has also been adapted to the manufacture of glued laminated lumber (2, 8).

The use of phenolic-film glues has also been reported to have increased recently in Australia. This may have been partly due to the lifting of import restrictions. In some sections of the industry, however, there is apparently a definite preference for the films, presumably because the number of control factors are reduced, spreads are eliminated, and assembly times are indefinite.

In Sweden, liquid phenol-resin glues used in plywood are entirely of the low-temperature curing type (230°–248° F.). Their use is increasing, due to the rising demand for exterior-type plywood. This range of cure temperature is lower than is commonly used in the American softwood plywood industry, where cure temperatures of 260° F. or higher are typical.

Other Plywood Glues

During the past year there seems to have been a change in the type of glue used for bonding interior Douglas-fir plywood, with a strong trend back to lower cost blood-soybean mixes. Primary reason for this change is said to be the economic pressure caused by current low prices for plywood. Some plywood mills are buying the necessary components from various sources and then preparing the blood-soybean mix within the plywood plant.

Blood glue, generally made of dry, soluble, whole blood, still seems to be a popular adhesive for both hot- and cold-press plywood. Blood-glue formulations with rather small proportions of special phenol resins have been popular for the hot pressing of interior-type plywood. One advantage seems to be the rapid cure cycles compared to straight resin formulations. These cure cycles include a hot-stacking process after removal from presses as an integral part of the curing cycle as is also typical for phenol-resin glues. One example was cited for ¾-inch, 5-ply Douglas-fir panels, where the cure cycle in the press was cut to 5¾ minutes with the blood-phenol formulation. With a typical furafil-extended phenolic-resin mix, this cure cycle was 6½ minutes. The cure with the blood-phenol resin was completed in the hot stacking later.

Other Types of Glues

The rubber-base adhesives, developed primarily for bonding plastic laminates to metals and other surface materials to wood and wood-base cores, continue to receive attention for other operations in wood bonding (9, 10). There still appears to be considerable variation in the properties of different rubber-base adhesives as far as both working characteristics and actual performance in bonds are concerned. The principal advantage of these rubber-base adhesives is their initial fast setting, making them adaptable to roller-pressure techniques. Such operations would be very interesting for a continuous and automated bonding operation, compared to the present batch-type pressing operations common in the wood industry. These so-called "contact cements" are generally of low solids content, either in a solvent system or in a water emulsion. They must be applied to both mating surfaces after which the adhesive film is dried to essentially a tack-free condition, and the surfaces are assembled and immediately pressed in a roller-type press. This double application offers some difficulties in conventional wood-bonding operations. Recently one adhesive manufacturer has offered an adhesive process, based on a neoprene contact cement, which can be applied to only one surface. This is presently intended for application to the edges of wall frames before bonding to the sheet facing material for building panels.

The use of neoprene-base solvent-type adhesives is still increasing in Sweden and the consumption in 1959 was estimated at 800 to 900 metric tons. There is a tendency reported for gluing wood to wood on a large scale where very short press periods are desirable.

The polyvinyl-resin-emulsion glues continue to be popular, particularly for assembly of furniture and doors. They have also been used to some extent for finger jointing of lumber for strictly interior use. Their limited moisture and water resistance makes them questionable for all-purpose finger-jointed lumber. Some improvement in creep resistance and water resistance for these polyvinyl-resin emulsions have been reported in Australia, where they are reported to be of increasing popularity, generally replacing animal glues in that country.

The use of polyvinyl-acetate glues in Sweden has been expanding with stress on the most fast-setting types with pressing periods as little as 3 minutes for edge-gluing. This has been made possible by increasing use of fast-closing compressed air presses in place of clamps.

A thermoplastic contact cement for veneer edge-gluing was reported in use in the Douglas-fir plywood industry (2). This product is said to require no heat for setting, has gap-filling properties, softens under heat, and is finding wide acceptance not only for core but for face stock as well.

Urea resins continue to be very popular, particularly in hardwood plywood and in furniture plywood and edge-gluing of core stock. Attempts to reduce the odor from free formaldehyde in such glues are still being made. This same problem is being faced in con-

nection with the urea-resin binders for particle board.

In Australia, organic catalysts are being used increasingly in the production of commercial urea-resin adhesives. Melamine hardeners are employed frequently with hot-setting resins made with wheat flour and extended urea, and wet strengths have been improved. Australian plywood mills have now reverted to phenolic resins for their marine-grade plywood after some unsatisfactory experiences with melamine-fortified urea glues for exterior applications.

Recently a cold-setting blood glue, available as a ready-mix glue similar to ready-mixed casein glues, has been offered on the West Coast. Unlike other blood glues, this one only requires the addition of water to prepare it for use. Such a cold-setting blood glue might be interesting as an adhesive for laminated timbers. Its adaptability for such operations has not yet been established.

Arsenic oxide has been found to have beneficial effects on dry and wet strengths of phenolic-resin glues in Australia and to shorten the setting time of the adhesive (11).

In Australia, tannin-formaldehyde formulations are being investigated with a view to their application as adhesives. Boilproof bonds have been obtained with mangrove, wattle, and other bark extractives (12). As particle board binders, both wattle and radiata tannin adhesives appear to have adequate bond strength. In plywood a resin combination of wattle tannin and formaldehyde resin gives a satisfactory bond with some veneer species. With other species, however, it has been necessary to add a small proportion of a suitable fortifying resin to obtain uniformly high wood failure. Control of pH is important in both adhesion and rate of gelation of wattle tannin-formaldehyde resins. Rate of gelation can also be adjusted by the addition of small amounts of soluble salts (13).

Interesting new cold-setting waterproof adhesives for Douglas-fir lumber were produced from a highly reactive extract from western hemlock bark (14). It was said to be possible to tailormake adhesives of this type to fit the operational requirements of the industry.

The Australians report increasing use of insecticides in plywood glue lines. While such treatments may not always give permanent protection in Australia, plywood panels of Lyctus-susceptible veneers with DDT in the glue lines have now been exposed for more than 9 years without any attack. Compatibility was dependent on several factors, including the adhesive and toxicant and its concentration and form. Dieldrin in small concentrations was compatible with urea-resin glues when the toxic was homogenized or used as wettable powder, but colloidal solutions produced joints with decreased wet strength. Arsenic was compatible with urea, phenol- and resorcinol-resin glues. Chlordane, dieldrin, aldrin, and benzene hexachloride in large concentrations decreased the strength of the phenolic-resin glues.

There has been a considerable increase in interest in the gluing of fire-retardant-treated wood recently because of certain new requirements for the protection of wood and wood products against fire. In Canada, interest in the production of fire-retardant-treated glued wood products is increasing, particularly in the plywood industry. Plant trials to date have not been very successful due to difficulties encountered in producing a suitable bond with the treated veneers. This has accentuated the need for considerable research in this field to provide information on the bonding of such materials and more particularly to develop adhesive formulations that will give satisfactory performance in production under these conditions.

Gluing of fire-retardant wood has also received considerable attention in the United States (15). One of the pressing problems is the development of a successful room-temperature-setting, resorcinol-type adhesive for use on fire-retardant-treated lumber.

Particle Board Binders

Urea resins continue to be the most prominent binder for particle board in this country. Greater emphasis is directed towards widening the markets for particle board; more attention is directed towards possible exterior applications. For this it is felt that a much more durable product must be produced.. Evidence at the present time suggests that phenolic-resin binders will be more durable than urea-resin binders in such board but that merely changing from urea-resin to phenolic-resin binders will not produce boards with the required exterior serviceability. The type of particle for such exterior board, the method of felting, pressing conditions, and other factors that are primarily concerned with controlling the amount of thickness swell when such boards become wet from liquid water must also be considered.

Some attention has been given to particle board binders made from bark extractives (16). Work conducted in New Zealand indicated that satisfactory particle board could probably be produced with a resin formulation consisting of bark extract and formaldehyde, with Pinus radiata bark as a source of the extract.

Glued Wood Products

Plywood: As cited earlier, the production of plywood has reached very high levels, particularly in softwood plywood. This has resulted from broadening the use patterns, with greatly increased emphasis on plywood sheathing. One of the most interesting recent developments has been the promotion of a variety of structural plywood components fabricated largely from Douglas-fir plywood. Plywood Fabricators Service, Inc., a subsidiary of the Douglas Fir Plywood Association, has grown in the past year to cover about 30 plants scattered around the country. It manufactures fabricated plywood and lumber components, such as box beams, curved panels, stressed-skin panels, and trusses. The quality control and grade-marking policies are administered by six regional laboratories (17).

The development of new plywood glues for the softwood plywood industry has been mentioned previously. Greater attention is being given to the glue-line quality in this softwood plywood (2). The gluing problems are being made somewhat more severe by a number of factors including 1) an ever-decreasing amount of old-growth, high-grade timber available for peelers; 2) higher costs of stumpage, shifting the emphasis towards greater utilization of logs including an increase in use of low-grade logs; 3) with the desire of promoting wider product acceptance, the plywood industry is constantly upgrading their glue-line standards; 4) the persistent market price fluctuations coupled with higher labor and operating costs place greater emphasis on lower-glue line costs and in most cases on shorter press times.

The Douglas-fir plywood industry has begun to use significant amounts of white-pocket veneer. Problems in the utilization of such veneer have been investigated by a number of laboratories. One of the problems has been the compression of the white-pocket veneers in standard hot-press schedules where it has been reported that the degree of compression increases as the percentage of white pocket increases (18). Total compression with any veneer type can be reduced through pressure control in hot pressing. Some compression during hot pressing is said to be partially recovered by later conditioning of panels. The problems of gluing exterior-type panels with low-grade Douglas-fir veneers have also been investigated recently (19).

The possibilities of using some of the western hardwoods for veneer and plywood have been investigated (20).

Estimates showed 23 billion feet of merchantable hardwood logs on the Pacific Coast, a valuable source of supply for hardwood plywood if certain technical problems can be resolved and customer acceptance obtained.

The question of quality control in the plywood industry continues to receive attention (21). The problem of reducing the checking of Douglas-fir plywood received some study (22). Stress relieving eliminated some of the face veneer checking irrespective of whether the tight or loose side was left out in the plywood. Checking of panels with the tight side out was more conspicuous than those with loose side out. No correlation was noted between the looseness of cutting and checking. Veneers from slow-grown Douglas-fir checked more conspicuously than those from fast-grown wood.

The production of very large sheets of plywood, particularly of softwood plywood, is growing (23, 24). Such plywood is used in house panels, boats, and trailers. The extra large dimensions are said to result in cost- and labor-saving benefits for the fabricators in certain of these specialized areas of construction. One manufacturer on the West Coast reports that the most commonly ordered plywood panels in the special sizes are 8 by 8 and 8 by 10 feet in 5/8- and 3/4-inch thickness. This firm also produces panels up to 4 feet wide by 10 feet long by 8 inches thick. These thicknesses are achieved by the use of special electronic presses. Special equipment is necessary to produce these large plywood sheets.

In Australia, production of very large sheets of plywood is also growing. Such panels are produced either by scarf jointing of standard-sized panels or by pressing the complete panel in a large press (23). Maximum size of the sheets available at present is 7 feet by 25 feet but it is proposed to make even larger sheets. These panels are used mainly for trailer and boat building, but the housing field is also being developed.

Edge and End Gluing: The gluing of short lengths into long lengths of lumber is continuing to receive much attention. This includes end-gluing for a rather broad range of requirements from merely holding short pieces of clear into trim or molding material to production of long lengths of lumber for the tension and compression sides of large laminated timbers where the full strength of the wood in the longitudinal direction must be approached. Much attention is being given to the design of the joint. The trend is away from the long and rather wasteful single scarf joint to various types of finger joints. Emphasis is on designs to reduce to a minimum the stress concentration at the ends of the fingers. Finger jointing of lumber at high moisture contents was investigated (25). As in other applications, the problems of gluing at high moisture conditions are the stresses on the joints and on the glued product itself due to subsequent drying in service.

Interest continues in the production of lumber panels that are both edge- and end-glued. This usually involves softwood lumber, and the edge- and end-glued panels are finding utilization for car lining in freight car rebuilding, for cabinet work, shelving, and other places where large standard-sized sheets of lumber are desirable. The production problems in producing such edge- and end-glued lumber have been considered by several firms and investigators (26). There are now several large-scale plants producing edge- and end-glued lumber of western softwoods in particular.

In Canada, end- and edge-gluing operations are expanding in a continuing effort to increase utilization and provide more attractive and convenient products for the consumer. End- and edge-glued panels produced in nominal 1- and 2-inch thicknesses, then resawn to approximately 1¼-inch thickness and machined, are being produced for decorative paneling. Standard-sized panels of end- and edge-glued oak and maple for heavy flooring, such as that used in trucks and other common carriers, have appeared on the market during the past year. The furniture industry in Canada is investigating the use of end joints for solid stock requirements to cut down the waste associated with the ever-increasing percentage of long cuttings required in modern furniture design.

In Australia, the biggest development in new products that stress better utilization is in finger jointing. Rapid development is reported in jointing of both softwoods and hardwoods (generally the eucalypts). Machines for joint profiling and gluing operations are usually imported from the United States or Europe. The process is particularly valuable for utilizing short lengths that would not otherwise find a market and for upgrading of stock. Polyvinyl resins are the prime glue for interior work, but urea resins and resorcinol and phenol-resorcinol resins are also receiving consideration in the more severe applications.

Laminated Products: The acceptance of laminated timber products both for architectural applications in churches, schools, and other buildings and for exterior service such as in bridge timbers continues (27). (See photo)

Laminated roof decking is now manufactured in thicknesses up to 5 inches and widths from 6 to 8 inches with lengths of 8 to 16 feet. The laminated product has a number of advantages (28) over solid decking: 1) It saves material by eliminating the machining of the tongue and groove, which is produced by offsetting the individual laminations in the gluing process; 2) much drier lumber can be used in the laminated product; and 3) different species and grades can be combined in the same board. Six species are now said to be available for the faces, which are exposed to the room below. These include western redcedar, western white pine, white fir, ponderosa pine, western larch, and Douglas-fir. Completely durable exterior glue lines are obtained with a phenolic resin, which is cured by high frequency, and is essentially a modification of conventional plywood glues.

In Australia, thinnings of Pinus radiata, of which there is an oversupply, have been used in the experimental production of railway crossties. In this application, two logs produced one tie. The logs were machined where necessary, glued with a resorcinol-phenol-resin glue and then impregnated with creosote. Tests have been reported successful, and the South Australian railways are now considering installation of such ties.

The gluing conditions and other problems involved in the production of glued laminated material continue to receive attention (29).

Other Glued Wood Products: One interesting Australian application reported was the development of a specialized laminated light pole for the landing lights in airports. This development is known as "Precision Visual Glide-Pass System." The pole is fabricated from a number of plywood disks connected by stringers and covered with a 1-millimeter plywood skin. (See illustrations). This assembly was developed in the Australian Aeronautical Research Laboratories in Melbourne. The structure is 25 feet high, about 5 inches in diameter, and weighs only about 16 pounds finished. The very low weight will prevent damage to incoming aircraft in the event of impact in the course of a deviation from normal land path. All components are immunized by copper-chrome arsenic preservatives and glued with resorcinol-phenol-resin glues cured by strip-heating methods.

In England, a firm is reported to be producing a "Fine-Line" veneer for furniture. Species selected at will for color, contrast, and other desirable

properties are veneered and glued together to make a slab, which is then sliced at right angles to the glue line, thus giving a regular stripe in the veneer which is used in the usual way where appearance is important. To formulate the adhesive for making the slab has been difficult as there must be no staining or visible glue line, and the slab must be softened after gluing to facilitate the slicing.

The combination of wood with other materials continues to receive attention (30). Composites of wood with other materials are recognized as having unusual properties and can improve the competitive picture of wood.

In Sweden, a new synthetic latex-based primer is offered to be applied to metal surfaces, enabling gluing of wood to different metals with several of the common woodworking glues, including resorcinol resins for exterior use. Solvent-based metal primers, based on synthetic rubbers as well as thermoplastic resins, have been used in the United States for some years in similar two-stage processes for bonding wood to metal.

Equipment

As recognized at the recent Symposium (1), the continued development of special gluing equipment is an important factor in the utilization of new adhesive bonding processes in the wood industry.

An automatic glue-mixing machine, designed particularly for edge-gluing operations, is being marketed.

Some door manufacturers are using composite grooving on rubber-roll glue spreaders, consisting of both helical and lengthwise grooves. Such groovings are reported to "wring off" on the sides and trailing edge of the door frame.

MAST ASSEMBLY developed in Australia for airport glide path. Here, stringers are stapled to disks during gluing. Central rod is later withdrawn. (Courtesy CSIRO, Australia.)

LAMINATED LIGHTPOLE for Australian airport is 26 feet long, 5 inches around, and weighs 16 pounds. Fabricated of a 1-millimeter plywood skin glued to plywood disks and Douglas-fir stringers, such masts are used on visual glide paths. (Courtesy CSIRO, Australia.)

The machinery for the rapid lamination of beams by the process developed at the Washington State Institute of Technology (31) is now available commercially.

Air-hose presses are reported to be finding increasing use in flush-door fabrication and in gluing of plastic laminates to cores. They are used as cold presses in batteries of two or more in sequence.

Hot-press equipment for plywood manufacturing and for the manufacture of particle board continues to become larger and more efficient. Recently a new West Coast softwood plywood plant is reported to have installed a 30-opening, simultaneously closing hot press. The simultaneous-closing feature is apparently accomplished by a separate mechanical lever system in which all the platens are pulled into the closed position first and then the final pressure is applied at one time by the hydraulic ram. This press is coupled with a conventional loading and unloading rack system with a new and unconventional automatic elevator system which feeds the assembled panels of veneer into the loader and unloads the finished panels from the unloader without any men operating the elevators themselves.

There is an increasing use of reactive two-component resin systems with very limited potlife, such as epoxy, polyether, and polyester systems for coatings, and to some extent as adhesives. To use such reactive systems effectively, the components must be metered and mixed at the point of application. For industrial application of this type, there have been recent developments in positive displacement air pump systems for pumping, metering, mixing, and dispensing. Two pumps, connected by a split bar mounted over an adjustable fulcrum, are operated by one air motor. The length of stroke of each pump is regulated by placement of the fulcrum; in the middle, a 50–50 mixture would be pumped, and such equipment is said to handle a ratio of 20 to 1 quite accurately.

The use of foamed adhesives has continued to receive limited attention in one or two plants in the United States, but the foamed adhesive system does not seem to be increasing significantly in this country at this time. One West Coast plywood plant is reported to have two foam glue units in operation with a bark-extended phenol-resin glue. Each unit supplies one spreader, foaming the glue as it is drawn through to furnish the spreader. A definite cost saving is said to result from lower weights of glue spread with the foamed glue.

Test Methods and Specifications

As the new adhesives and bonding processes appear and as the variety of new glued wood products increases, there is a greater need for new and better test methods to evaluate the quality of gluing as well as to evaluate the glued wood product as a whole.

In the past year, considerable attention has been directed towards establishing industry standards for laminated timber construction under the auspices of the American Institute of Timber Construction. A number of the regional lumber associations are also developing standards for glued lumber products, including edge- and end-glued products as well as some laminated products.

A revision of the commercial standard for hardwood plywood, CS 35–56, is now underway (32), and two new standards on prefinished wall panels and on laminated block flooring are being developed. Commercial Standard CS 122–49 on Western Softwood Plywood is also under revision.

A recent study to correlate plywood bond durability to laboratory tests and on exterior weathering has been reported (33). This study confirms the earlier conclusion that the higher the wood failure in plywood shear tests

after laboratory boiling and drying exposures, the greater the durability on exterior weathering. This also affirms the soundness of the present exterior-type test in Commercial Standard CS 45–60 for Douglas-fir plywood.

In Australia, the plywood standard for marine-grade plywood is being revised, but the basic principles of the construction remain unaltered. Such marine-grade plywood can be produced only from certain listed species. A new standard is said to propose widening the range of species and admitting other species with properties similar to the ones specified. A cold-soak test for glue-line quality is introduced, and the soaking time in boiling water is extended to 72 hours. Knife test results are being evaluated only by observations of wood failure.

In Europe, there is still considerable difference in the opinions about the tests of exterior plywood. In England, the 72-hour-boil test is required, and it also appears to be adopted in France. In Germany, the American test method of two 4-hour-boil periods with a drying period of 65° C. between is considered too time consuming. England prefers a long boiling period only to eliminate melamine resins. According to current developments in Europe, this appears justified since exterior tests in England are reported to show that phenolic plywood resins are superior to all other wood adhesives in weather resistance. The correlation between these long boiling tests and other tests with exterior weathering still needs to be established.

A commission recently appointed by the Federation of European Plywood Industries, which consists of representatives from England, France, Germany, and Austria, has recommended a uniform European shear test specimen. It is to be 100 millimeters long, 25 millimeters wide, and will be cut through the veneers from both sides to the glue joint. Comparative tests in Germany and France have shown that with this test specimen the least variation in the single plywood panel can be determined and that this shear test will readily demonstrate variations in comparing different adhesives. This shear test is intended only for adhesives for exterior plywood. Interior plywood and semi-exterior plywood glued with melamine and fortified urea resins and glues are tested according to the English knife test with the 15- by 15-centimeter specimen. This test method is required under British Standard B.S. 1455:1956.

Special Research Studies

Although no attempt has been possible to cover the many interesting research studies on glues and gluing processes in the wood industry, a few studies chosen at random may be of interest.

The question of degree of cure of resin adhesives in wood bonds has been receiving some further attention (34). Northcott in this reference thinks that undercured phenolic-resin bonds are the major cause of the low wood failures in softwood plywood. Other factors are veneer-drying history, assembly time, veneer-storage time, and absorbed moisture, all of which contribute to undercure. Such undercured joints may cure further in service. There is some question of whether the wood failure readings on specimens will show undercure effects adequately. There seems to be a difference of opinion among different investigators as to whether curing or hardening of thermosetting resins continues at normal room conditions after curing at elevated temperatures. Plath in Germany feels that this further cure may happen with urea resins but is doubtful with Duro-plasts. Melamine resins apparently also further harden after the pressing period. Plath reports observing that further hardening or curing of such room-temperature-curing resins occurs during boiling tests, although this is doubtful with phenol resins. This study is being continued.

Some interesting information of a fundamental nature has been reported on the effect of the wettability of wood on glue-line behavior with two urea resins (35) and on the relationship between the chemical properties of wood and adhesives (36).

As was reported earlier in this review, the need for much additional fundamental research into the problems of gluing was well recognized at the recent Adhesives Symposium in Madison (1).

Literature Cited and Supplemental Bibliography

As in previous reviews, two separate bibliographies are included. The first numbered bibliography refers directly to references cited in this report. The second supplementary bibliography covers additional references collected by the librarians of the College of Forestry at the University of Washington, by Mr. Ray Currier of the Oregon Forest Research Center, and as supplied by several other correspondents.

1. Anon. 1960. Proceedings of the symposium on adhesives for the wood industry. U. S. Forest Prod. Lab. Report 2183.
2. Anon. 1960. There's excitement in glues. The Lumberman 86 (13): 114.
3. Anon. 1960. Phenol makers head for plywood country. Chemical Week 87 (7): 89.
4. Stensrud, R. K. 1960. Automation with dry-film adhesives. Forest Prod. J. X (8): 392.
5. Preusser, H. M. 1960. Wet-web glue lines reduce layup cost. Forest Prod. J. X(8): 400.
6. Sullivan, R. A. 1960. New equipment developments point to continuous layup system. Forest Prod. J. X(8): 398.
7. Herstrom C. A. 1960. Economics of automation in plywood manufacture. Forest Prod. J. X(8): 396.
8. Anon. 1959. New press shortens cycle for laminating. The Lumberman 86 (11): 76.
9. Blomquist, R. F., and W. Z. Olson. 1960. An evaluation of 21 rubber-base adhesives for wood. Forest Prod. J. X (10): 494.
10. Hemming, C. B. 1960. The technology involved in using elastomeric adhesives. Forest Prod. J. X(1): 30.
11. Hirst, K., and K. F. Plomley. 1959. Influence of arsenic trioxide on bond strength and setting time of phenolic glues. Holzfurschung 13(6): 182.
12. Plomley, K. F., J. W. Gottstein, and W. E. Hillis. 1957. Tannin-formaldehyde adhesives. C.S.I.R.O. Forest Prod. News Letter No. 234, September, p. 6.
13. Plomley, K. F. 1959. The effects of soluble salts on the gelation of tannin-formaldehyde. Aust. J. Appl. Sci. 10 (4): 494.
14. Herrick, F. W., and R. J. Conca. 1960. Use of bark extracts in cold-setting waterproof adhesives. Forest Prod. J. X (7): 361.
15. Ropella, L. A. 1960. Adhesives and procedures for gluing fire-retardant-treated wood. Forest Prod. J. X(10): 513.
16. Hall, R. B., J. H. Leonard, and G. A. Nicholls. 1960. Bonding particle boards with bark extracts. Forest Prod. J. X (5): 263.
17. Countryman, D. 1960. New structures with plywood. Forest Prod. J. X(10): 529.
18. Currier, R. A. 1960. Compression of white-pocket veneer in hot-pressed Douglas-fir plywood. Forest Prod. Jour. X(8): 409.
19. Raymond, R. C. 1960. Exterior gluing of low-grade Douglas-fir veneer. Forest Prod. J. X(1): 36.
20. Koehler, P. H. 1960. The potential of western hardwoods for veneer and plywood. Forest Prod. J. X(6): 294.
21. Raymond, R. C., J. M. Hine, K. K. Graves, and H. W. McClary. 1960. How can the plywood industry improve control of glue bond quality? Forest Prod. J. X(4): 205.
22. Elmendorf, A.,and T. W. Vaughan. 1960. Means for reducing the checking of Douglas-fir plywood. Forest Prod. J. X(1): 45.
23. Anon. 1960. Jumbo plywood panels. Indus. Woodworking, April, p. 33.
24. Anon. 1958. Largest plywood panels in the world. Veneer and Plywood 52(6): 35.
25. Currier, R. A. 1960. Finger jointing at high moisture content. Forest Prod. J. X(6): 287.
26. Syme, J. H. 1960. Factors for efficiency in lumber end- and edge-gluing operations. Forest Prod. J. X (5): 228.
27. Oviatt, A. E., Jr. 1960. Architectural characteristics of laminated wood. Forest Prod. J. X(5): 225.
28. Hoyle, R. J. 1960. One company's experience in providing laminated wood building products. Forest Prod. J. X (3): 156.
29. Driehuyzen, H. W., and R. W. Wellwood. 1960. Effect of temperature and humidity of glue room on open assembly time. Forest Prod. J. X(5): 254.

30. Carlson, C. L. 1959. Adhesives for dissimilar materials. Forest Prod. J. IX (11): 431.
31. Anon. 1959. Revolution in laminating—glued-up beams in 7 minutes. Wood and Wood Producas 64(3): 44.
32. Groah, W. J. 1960. Commercial standards for hardwood plywood products. Forest Prod. J. X(10): 536.
33. Northcott, P. L., and H. G. M. Colbeck. 1960. Prediction of plywood bond durability. Forest Prod. J. X(8): 403.
34. ————, ————, W. V. Hancock, and K. C. Shen. 1959. Undercure—Casehardening in plywood. Forest Prod. J. IX(12): 442.
35. Freeman, H. G., and F. F. Wangaard. 1960. Effect of wettability of wood on glue-line behavior of two urea resins. Forest Prod. J. X(6): 311.
36. Freeman, H. A. 1959. Relation between physical and chemical properties of wood and adhesion. Forest Prod. J. IX(12): 451.

Supplementary Bibliography

Bain, S. 1959. Veneering laminated plastics to lightweight core materials. Woodworking Digest (Hitchcock's) 61(8): 78–79.
Berger, V., and J. Skripen. 1959. Contribution to elucidation to the effect of acid hardener on wood in gluing with phenolic glues. (In Czech.) Drevarsky Vyskum 4(1): 107–120.
Bergin, E. G. 1959. Effect of wood moisture content on gluing. Forest Prod. Lab., Can. F.P.L. Tech. Note 12, 14 p.
Bergin, E. G. 1959. Moisture content and gluing. Wood 24(12):492.
————. 1959. The selection of a suitable adhesive. Timber Technol. 67 (2240): 257–259.
Blomquist, R. F. 1959. Wood gluing and laminating: Today and Tomorrow. Wood and Wood Prod. 64(3): 40–41, 60.
Booth, C. C., G. P. Hancock, and J. M. Hine. 1959. Elastomeric adhesives—their uses in forest products. Forest Prod. J. 9(10): 337–339.
Booth, H. E., and M. Mawby. 1959. The extension of urea-formaldehyde plywood glues and wheat flour. Aust. Timb. J. 25 (11): 40–53.
Borgin, K. 1959. Polyester resins as a binder; the moulding of wood particles. Timber Technol. 67(2246): 282–286.
Brown, G. E. 1959. End and edge gluing process. Northw. Wood Prod. Clinic Proc. 14: 72–79.
Bryant, B. S., J. D. Blanchard, and O. F. Campbell. 1959. Industrial uses of an automatic machine for glue bond testing. Forest Prod. J. 9(5): 172–176.
Byers, Ted. V. 1959. Short edge gluing. Northw. Wood Prod. Clinic Proc. 14: 68–97.
Carruthers, J. F. S., and W. Wilson. 1959. The control of a radio frequency generator for experimental work in glue setting. Wood 24(9): 373–375.
————. 1959. Heat penetration in the pressing of plywood. Forest Prod. Res. Bull. No. 44: 22.
————, and B. H. Paxton. 1958. Aging of glued joints set by radio frequency heating. Timber Tech., December.
Chugg, W. A. 1959. Manufacture of glued laminated structures.
Pt. 1—Introduction. Structural advantages. Timb. Tr. J. 229 (4315): 87–88. May 23.
Pt. 2—Factory layout . . . Timb. Tr. J. 229(4317): 83–84. June 6.
Pt. 3—Factory equipment. Timb. Tr. J. 230(4327): 91–94. August 15.
Pt. 4—Factory control and inspection . . . Timb. Tr. J. 230(4331): 82–85. September 12.
Pt. 5—Timber—species and grading. Timb. Tr. J. 230(4332): 86–90. September 19.
Pt. 6—Timber—moisture content and end joints. Timb. Tr. J. 231 (4434): 87–92. October 30.
Clad, W. 1959. Prüfung von Holzleimen. (Testing wood glues) Holz Ruh-u Werkstoff 17(1): 23–29.
Eby, R. E. 1959. In laminating, the surface hasn't been scratched. Wood and Wood Prod. 64(3): 42–43.
Egner, K. 1929. Study of (wood) fibers damaged by acid hardened synthetic resin glues. Aust. CSIRO. Transl. No. 4282. 6p. + 4 plates. Transl. by E. Bolza from Holz-Zbl. 78(135): 1857–1858 in 1952.
Electronic gluing of hardboard. Woodworker, Indianap. 78(6): 15.
Erickson, E. C. O., and W. F. Faulkes. 1959. Basic properties of yellow birch laminates modified with phenol and urea resins; information reviewed and reaffirmed. U. S. Forest Prod. Lab., Madison. Report 1741, 14 p.
Fleischer, H. O. 1959. Beech for veneer and plywood and the gluing of beech. Ntheast. Logger 7(8): 28–30.
Four experts discuss trouble shooting glue problems: 1959.
1. Gill, R. C. Animal glues for assembly and edge gluing.
2. Booth, C. C. Urea resins for hot-and-cold press hardwood plywood.
3. Clark, L. E., Jr. Urea resins for RF and heated-platen edge gluing.
4. McCormack, P. H. Polyvinyl resins for high-pressure plastic laminating. Forest Prod. J. 9(6): 11-A–16-A.
Freeman, H. A. 1959. Relation between physical and chemical properties of wood and adhesion. Forest Prod. J. 9(12): 451–458.
Ghosh, A. G. 1959. Gelation time studies of some resorcinol adhesives. J. Sci. Industr. Res., India 18A(2): 58–60.
Gilman, J. W. 1959. Hot pressing with melamine and melamine urea adhesives. Northw. Wood Prod. Clinic Proc. 14: 83–86.
Glues and gluing; problems of high frequency gluing of dimension. Woodworker, Indianap. 78(10): 32. 1959.
Hadley, D. 1959. A boil-proof bond by cold press. Veneers and Plywood 53 (10): 15.
Hine, J. M. 1959. How can the plywood industry improve control of glue-bond quality? (condensed) Woodworking Digest (Hitchcock's) 61(8): 81–85.
Hirst, K., and Plomley, K. F. 1959. Influence of arsenic trioxide on bond strength and setting time of phenolic glues. Holzforschung, Berlin 13(6): 182–184.
Horioka, K. Studies on plywood (Rep. No. 10). On the effects of addition of paraffin wax emulsion to urea-formaldehyde resin adhesive upon the adhesion property of plywood. Bull. For. Exp. Sta., Meguro, Tokyo, No. 113: 51–56. 1959.
Horioka, K., M Noquchi, and M. Saito. 1959. Research for the improvement of wood (Rep. No. 8). On the latent hardener of urea-formaldehyde resin adhesive. Bull. For. Exp. Sta., Meguro, Tokyo, No. 113: 21–36.
Horioka, K. et al. 1959. Research for the improvement of wood (Rep. No. 7). The synthesis and its property of adhesion of urea-formaldehyde resin adhesive made from radioisotope urea. Bull. For. Exp. Sta., Meguro, Tokyo, No. 113: 1–20.
"Hot-Melt" adhesives. 1959. Adhesives and Resins 7(12): 113–116.
Hunt, I. H. 1959. Gluing of treated timbers. N. Z. Timb. J. and Wood Prod. Rev. 5(12): 37–38.
Hyler, J. E. 1959. Accurate jointing and splicing. Veneers and Plywood 53(10): 14, 18.
Knight, R. A. G. 1959. The assessment of bond quality in glued wood joints. Plastics Institute Translation and Journal 27 (71): 153–158.
————. 1959. The durability of cold-setting phenolic and resorcinol glues in wooden structural units exposed to the sun. Wood 24(8): 330–332.
————. 1960. Requirements and properties of adhesives for wood, (British) Forest Products Res. Lab., Report No. 20, Third Edition with Amendments.
————, and L. S. Doman. 1959. Analysis of the mechanical and knife test for glues and plywood used in British Standard Specifications, J. Inst. Wood Sci. December.
————. 1959. The efficiency of adhesives for wood. Summary 4. Forest Prod. Res., London, 20 p. & 1 tbl.
————. 1959. The efficiency of adhehives for wood; Summary of test results as at January 1959. Forest Prod. Res., London, Bull. 38, ed. 2, 21 p.
————, and L. S. Doman. 1959. Gluing oak with resorcinol resins. Wood 24(9): 365–369.
Krier, John P. 1959. Glues and gluing. Northw. Wood Prod. Clinic 14: Panel 4: 67.
Lamination Symposium. 1959. N. Z. Timb. J & Wood Prod. Rev. 5(8): 46–48.
Mann, J. W. 1959. New electrode designs to spur high frequency gluing. Wood, Chicago, 64: 58.
Marian, J. E., and A. Wissing. 1959. The utilization of bark. III. The utilization of polyphenols in spruce bark extractives in adhesives. Svenska TräforsknInst. (Träteknik.) Meddelande 107B.
Maxwell, J. W., and others. 1959. A search for better particle board adhesives. Forest Prod. J. 9(10): 42A–46A.
Miller, D. G. 1950. For plywood and other bonded materials: sonic detection of blisters. Forest Prod. J. 9(8): 243–247.
Mori, S., and S. Imura. 1959. Studies on foaming adhesives. VII. Durability test on the foaming urea-resin glued plywoods by using a weather meter. (In Japanese) Japan Wood Res. Soc. J. 5(3): 99–101.
Moruskin, G. V. 1959. O rezimnyh fatorah pri skleivanii drevesiny s podogrevom TVC. (Schedule factors to be considered in gluing wood by radio frequency heating.) Derev. Prom. 8(2): 19–20.
Makamura, G. I. 1959. Effect of hot-pressing upon the surface roughness of beech veneer. (In Japanese) Japan Wood Res. Soc. J. 5(2): 69–74.
Niwa, T. 1959. Extension of resin glues by the addition of milled wood from which pentosan has been extracted. (In Japanese). Hokkaido U. Col. Exp. Forests Res. B. 20(1): 175–181.
Norman, T. S. 1959. The Philippine plywood and the glue industry. Lumberman (Manila) 5(2): 26–27.
Northcott, P. L., H. G. M. Colbeck, W. V. Hancock, and K. C. Shen. 1959. Undercure—casehardening in plywoods. Forest Prod. J. 9(12): 442–451.
Pound, J. 1959. The effect of moisture on radio frequency heating. Wood 24(11): 452–455.
————. 1959. Glue line pressures with radio frequency heating. Wood 24 (8): 336–339.
————. 1959. Laminating shapes with radio frequency heating. Wood 24 (3): 101–104.

———————. Radio frequency heating in wood gluing. Beama J. 66(4): 148–151.

Richards, D. B., and F. E. Goodrick. 1959. Tensile strength of scarf joints in southern pine. Forest Prod. J. 9(6): 177–179.

Sandweg, K. and H. Bruning. 1959. Hochfrequenzverleimung von Schictparkett. (Radio frequency gluing of layer parquet flooring.) Holz-Kuerier, Wien 14(35): 12–14.

Selbo, M. L. 1959. Summary of information on gluing of treated wood. U. S. Forest Prod. Lab., Madison, Report 1789, rev., 21 p.

Skaar, J. A. 1959. Lumber laminating. Northw. Wood Prod. Clinic Proc. 14: 87–90.

Suchsland, O. 1959. The strength of glue joints in wood obtained with minimum glue spread. Quart. Bull. Mich. Agric. Exp. Sta. 41(3): 577–599.

Tamblyn, N., E. W. B. DaCosta, and F. J. Gay. 1959. Preservative treatments for plywood by momentary dipping of green veneer. Aust. Commonwealth Sci. and Indus. Res. Organ Div. Forest Prod. Technol. Paper 6, 8 p.

Thomas, R. J. 1959. Gluing characteristics of determa (Ocotea rubra.). Forest Prod. J. 9(8): 266–271.

Thomsen, R. L. 1959. Paper to wood gluing. Northw. Wood Prod. Clinic Proc. 14: 80–83.

Wood glue reference guide. 1959. Wood, Chicago, 64(3): 72–76.

Ziegler, J. L. 1959. Making glue go further: mechanized foaming of adhesives. Forest Prod. J. 9(7): 233–235.

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A REVIEW OF

Progress in Chemical Conversion[1]

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This review is a continuation of last year's "Review of Chemical Utilization." It presents complete literature surveys on bark, lignin, and extractives as well as sections on pulping, charcoal, and wood hydrolysis, covering developments in these fields during the past year.

Pulping

A COMPREHENSIVE BIBLIOGRAPHY of the pulp and papermaking literature for 1959, including many references to the chemical pulping of wood, has been compiled by Weiner (633).[2] A review of 44 literature references on the suitability and limitations of hardwood pulps produced by the various semichemical, chemimechanical, and mechanical processes for their use in newsprint paper was presented by Swartz (595).

Hartler, Sundberg, and Bausch (57, 272) measured the loss in strength of sulfite and sulfate pulps because of damage to fibers in the cutting of chips with dull chipper knives. Kraft showed little or no loss in strength, but both acid sulfite and bisulfite pulps suffered appreciable, and approximately equal, loss in strength from this source.

A new continuous pulping process developed at the University of Florida (33) is based on the theory that liquor penetration into chips does not depend on osmosis, but that the reaction follows a reaction interface into the chip at a rate depending on liquor concentration and temperature. Chip size is the only other important processing variable.

A SPECTROPHOTOMETRIC METHOD for the quantitative determination of lignin in small samples of wood (5 to 100 milligrams) is under development by the U. S. Forest Products Laboratory. Here, chemist D. B. Johnson operates a ratio recording spectrophotometer.

Sulfite and Multistage Pulping: Interest has continued to run high in the pulping industry on the subject of sulfite pulping reactions and multistage processes. Three methods of sulfite pulping spruce were compared by Vethe, Lorås, and Løshbrandt (623); (a) With a conventional one-stage calcium-base acid sulfite but cooking under extremely mild conditions, with a combined sulfur dioxide of 1.2 grams per 100 cubic centimeters and temperature of 118° C.; (b) a one-stage sodium bisulfite digestion at pH4 to 4.5 and maximum temperature of 155° C.; and (c) a two-stage process using a sodium monosulfite solution at pH 9 to 10 and 125° C. for 1 hour, followed by a conventional calcium-base

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[2] Numbers in parentheses refer to the Literature Cited at the end of this review.

acid sulfite of usual composition but at a maximum temperature of 130° C. For an equal degree of delignification, the two-stage process gave a higher yield of pulp, presumably because the high combined sulfur dioxide in the first stage caused lower rates of hydrolysis and crystallization of the hemicellulose.

Kosilova and Nepenin (344) reported that the sulfonation of carbohydrates that accompany the sulfonation of lignin amounts to 30 to 35 percent of the total bound sulfur. The sulfonic acid groups in the lignosulfonic acids were studied by Gierer, Alfredsen, and Soderberg (616). From one-third to two-thirds of a fraction that is rapidly split off by acid treatment may be a benzyl-sulfonic group, and a fraction split off more slowly may be either benzyl-sulfonic acid groups of unknown type or, more likely, sulfonic acid groups attached to carbon atoms other than the benzyl carbon atom. Cordingly (142) described sulfonic acids prepared from xylose and arabinose.

Räsänen and Luctonen (499) reported on the production of dissolving grade pulp at the mill of Rauma-Repola Oy, Rauma, Finland, using a multistage process consisting of a soda-base acid sulfite liquor in the first stage and caustic soda containing a little sodium sulfite in the second stage. The recovery of chemicals is also described. Lagergren and Lunden (365) and Wilson (646) describe the two-stage soda-base sulfite pulping and chemical recovery processes of the Stora pulp mills at Skutskär, Sweden. Annergren and Rydholm (24) found that the pulping of spruce with a neutral sulfite cooking stage preceding a normal acid sulfite digestion gave rayon-grade pulp with lower alpha-cellulose content than does conventional single-stage acid sulfite cooking. The pulp contained more glucomannan, which was attributed to a rearrangement of the molecules, resulting in less accessibility of the cellulose to hydrolysis.

According to Stockman (585), sulfite cooking without base is possible under certain conditions and gives paper and viscose pulps with normal yield-chlorine number relationships. The sulfonation can be accelerated by small additions of a base or a soluble sulfate.

Ogiwara and Shimoda (446) found that ammonium sulfate is formed as a degradation product in ammonium sulfite monohydrate when it is stored either in crystal or dissolved form. When the chemical was used in sulfite cooking, the effect of this contamination was to accelerate the cooking reaction, decompose the sulfur dioxide, and lower the yield of pulp. There was no effect on pulp quality. Using special impregnating techniques, Ellefsen (172) studied the dissolution of lignin and carbohydrate in ammonia-base sulfite cooking, with results that indicated there were two fractions of lignin differing significantly in accessibility. Sapotnitskiĭ and Moskaleva (537) digested glucose solutions with sulfite liquors containing aromatic or aliphatic aldehydes. The latter reduced the degradation of the glucose considerably, whereas the former showed no such benefit compared with digestions in which the aldehydes were absent.

Cooking with a magnesium bisulfite liquor (Magnefite process, Wilson and O'Meara (647) obtained greater pulp yields, faster cooking, reduced steam consumption, and had to process less spent liquor if the free cooking liquor was drained at the end of an impregnation stage and the cooking completed by direct steaming in the vapor phase. Samuels (531) found that the heartwood of Douglas-fir required more chemical for pulping by the Magnefite process than the sapwood. Pretreatment with hot water improved the pulping of the heartwood.

After defining and comparing the conventional sulfite and sulfate processes, Giertz (228) discusses recent sulfite process modifications, including the semichemical and chemimechanical processes, soluble-base cooking, cooking without base, bisulfite and combination processes, cooking with high sulfur dioxide content and low pH, and chemical recovery processes.

Tomlinson (610) and Hamilton and Thompson (267) explained the fundamental differences in the chemical and physical properties of sulfite and kraft pulps and gave reasons for the differences.

Alkaline Pulping: Dostal, Marraccini, and Kleinert (158, 159, 339) reported on extensive studies on the sorption of dilute solutions of alkali by wood at various concentrations and pressures. Alkali sorption in the outer layers of the wood was found to be a main factor in the alkali distribution within the wood, the latter not being identical with the moisture distribution. Nonuniformity of alkali distribution within the wood was caused by sorption in outer layers depleting the liquor of alkali. Penetration was least marked through the radial and tangential directions and greatest along the grain direction (fiber axis). Complete penetration was rapidly obtained with alkaline pulping liquors in wood chips of up to 1/10 of an inch in thickness and 1 inch in length in the grain direction. The hydrosulfide ion produced by the hydrolysis of sodium sulfide in kraft liquor is only slightly sorbed in comparison to that of the hydroxide ion.

The addition of 1 percent of sodium borohydride (based on wood) to the cooking liquor increased the yield of pine sulfate pulp from 46.7 to 51.2 percent (271). This increase was due largely to the retention of glucomannan in the pulp and was attributed to a reduction of carbonyl groups by the borohydride, thereby lowering the solubility of the polysaccharides. The pulp was brighter and more readily beaten, with unchanged strength properties, than the normal sulfate pulp.

Mill-scale experiments on the effect of adding elemental sulfur to the digester prior to liquor addition in the sulfate pulping of southern pine were made by Cox, Owen, and Fuller (146). When sulfur was added to create an equivalent sulfidity of 27 to 30 percent, relatively "soft" pulps with lower rejects and optimum strength were produced. Peckham and May (468) used sulfate pulping liquor enriched with polysulfides for pulping southern pine and obtained about 2 percent more screened pulp than when pulped by the usual kraft process, but the strength was a little lower. Scopp (36) claims in U. S. Patent No. 2,944,928 to obtain about 8 percent increase in yield and higher pulp strength by substituting sodium or potassium polysulfide for sodium monosulfide in the white cooking liquor.

Sulfate and groundwood pulping tests on pole-blighted and healthy western white pine (540) showed that pulps of good quality can be produced from both types of wood, although those made from healthy trees were on the average slightly higher in strength. The sulfate pulping of redwood (398) gave pulp with low yield but excellent strength. The unbleached pulp was suitable for making linerboard and bag paper, and the bleached pulp could be used in milk carton stock and bond and offset papers. Sulfate, sulfite, neutral sulfite semichemical, and groundwood pulping and papermaking experiments on aspen grown in Colorado (308) demonstrated that this wood was equivalent to aspen grown in the Lake States for making these types of pulp and the papers made from them. Sulfate and prehydrolysis-sulfate pulps made for nitration from loblolly pine, Douglas-fir, and sweetgum (563) were observed to show strong correlation between certain strength properties and their pentosan content.

Semichemical and Chemimechanical Pulping: Novel methods of producing semichemical pulp from

spruce, beech, and poplar for the making of rayon-type pulp were investigated by Jacopian and Schorning (317): (a) an aqueous-alcoholic medium in the presence of sodium sulfite and sulfuric acid, (b) a modification of the so-called "baseless" sulfite process, and (c) the neutral sulfite semichemical process. Several procedures for purifying the pulps were used.

The refined pulps were obtained in relatively good yield, but further studies are needed to improve their reactivity and processability. Jayme, Schwartzkopff, and Kleppe (323) compared normal cooking with preimpregnation and vapor-phase cooking in the neutral sulfite semichemical pulping of pine and beech. Treatment with concentrated liquor followed by removal of the excess chemical and cooking in the vapor phase gave greater yields—on a lignin-free basis—and the pulp was brighter. The strength was increased in proportion to the lignin decrease in most cases.

Greiner (253) examined the feasibility of mixing cold soda pulp made from hardwood sawdust with neutral sulfite semichemical pulp made from chips for making corrugating board and found that up to 20 percent of the sawdust cold soda pulp could be mixed with the neutral sulfite pulp without changing the properties of the corrugating medium. Laundrie (373) reported on the continuous cold soda pulping of red alder, tanoak, madrone, and bigleaf maple for use in making corrugating board. Various types of chemimechanical pulps made from both hardwoods and softwoods were compared by Chidester, Laundrie, and Keller (130) in regard to their properties and energy consumptions. Newsprint and magazine papers were made by substituting high-yield hardwood neutral sulfite pulp and high-yield softwood two-stage acid-alkaline and neutral sulfite chemimechanical pulps for the conventional softwood groundwood and sulfite components in these papers.

Acid and Hydrotropic Pulping: A nitric acid process for pulping chips, sawdust, and other wood waste was studied at the University of California (30). The spent nitric acid liquor is drawn off, and the chips are treated with an ammonium hydroxide solution. The second-stage spent liquor is combined with the first-stage liquor and the excess ammonia distilled off. The neutral solution remaining after concentrating appears to be suitable for use in fertilizers, and the wash water effluent might be added to irrigation waters.

McKee (387) described processes for making chemical and semichemical pulps with sodium xylenesulfonate solutions. Treatment of spruce for three hours to 300° F. with 30 percent sodium xylenesulfonate gave a 50 percent yield of paper grade pulp. A 1 percent solution of the hydrotropic agent can be used at atmospheric pressure or under mild pressure. With these conditions no lignin is removed, only part of the pentosans. Softer pulps are obtained when a buffering agent such as ammonia or calcium hydroxide is added to the hydrotropic solution (387a).

Byproducts: New plants for the production of dimethyl sulfide and dimethyl sulfoxide from kraft mill relief and blow gases were described (29, 37). At one mill the estimate of annual production will be 10 million pounds of dimethyl sulfide, 5 million pounds of dimethyl sulfoxide, and 1 million pounds of methyl mercaptan. Enkvist (176) heated concentrated spent sulfite liquor and sulfate black liquor with sodium sulfide and caustic soda and obtained up to 50 percent of ether soluble compounds (based on weight of organic matter in the liquor). A phenolic fraction amounted to 200 kilograms per ton of pulp, had novolac-like properties, and was hardened with substances like hexamethylene-tetramine. Among the reaction products were pyrocatechol (about 3 percent) and such derivatives as 4-acetopyrocatechol, protocatechuic aldehyde, and protocatechinic acid. Vanillin and acetoguaiacone, each amounting to about 2 kilograms per ton of pulp, were obtained.

Residues: A report by Linkhart (380) describes the use of a continuous digester for the sulfate pulping of softwood sawdust and shavings. The material is pulped to a 2 or 3 points higher permanganate number than are chips in a batch digester so as to obtain better strength. The sawdust pulp is blended with chip pulp in proportions of 15 to 20 percent without effect on strength, compared to that of the chip pulp. Chidester (129) reported progress on tests to characterize sawdusts by screen classification and fiber-length measurements. The weighted average fiber length of the fraction of softwood sawdusts that passed a 16-mesh screen is in the range of the average fiber lengths of hardwood sulfate pulps.

Charcoal Production and Thermal Degradation

There is a continued and widespread pattern involving the production of charcoal. In domestic effort there is evidence of expanded conventional means as well as methods which are newer and more recently applied. In the previous "Review of Chemical Utilization" (467), a pilot operation (153), employing continuous forced feed, horizontal multitube carbonization of wood fines was described. This type of conversion has been extended to a commercial operation with plant capacity of 12 tons of charcoal fines a day diverted to a nearby plant for briquetting. Low value wood fines from an adjacent mill provide the chief source of raw material for carbonization.

That the continuous coaling of mill waste fines provides further challenge toward profitable carbon production can be pointed out by the concerted interest of others in this field. While two fairly recent developments have not as yet reached plant production, it is understood they await only trial installation for anticipated full-scale operation. One of these methods quite widely explored (440) includes the use of a Heereshoff type furnace originally designed for processing ore. Such a vertical chamber is equipped with a number of hearths from which the material being heated is scraped from hearth to hearth in downward continuous flow. The other method makes use of a vertical retort employing fluidized bed technique with forced air supply for process combustion of the formed volatiles (561). Recovery of the carbon fines is accomplished by cyclonic separation. Both methods reportedly provide suitable possibilities for economic conversion of mill or prepared wood fines. A study involving the carbonization of partially extracted pine chips by use of superheated air (383) suggests further interest in methods for wood particle conversion and utilization. In this case, the vertical furnace was equipped for airborne pitch separation. The separated resin product was considered suitable for use in reclaimed rubber. The liquid product containing methanol, volatile acids, and esters when aspen, spruce, and birch were processed similarly (384) was closely similar to the distillate obtained by the usual dry distillation. The advantage of the presence of nitrogen (615) to reduce the extent of secondary reactions during the dry distillation of wood has been likewise investigated. The yields of tar and acids using 0.6 millimeter birch particles were greatly increased in these experiments over those obtained by conventional processing. Other work has been discussed on the use of an oxidizing system (359). By this system, the distillation of wood is conducted with oxygen or air at 16 atmospheres and 100° to 160° C. in the presence of sodium carbonate or calcium hydroxide. Yields of 50 to 60 percent volatile acids of which 70 to

85 percent was acetic and 15 to 30 percent formic were reported. Creosote oils from the thermal decomposition of beech were heated to 180–250° in the presence of silicates (as catalysts) activated by burning with coke (573). The yield of phenols with more than one OH group was proportional to the temperature.

A markedly different batch type vertical retort reportedly free of moving parts and requiring no auxiliary charcoal coaling chambers has begun commercial operation recently. A production level of about 2½ tons per day is reported utilizing essentially veneer and furniture plant short length waste. The 8-foot-diameter retort is fitted with five 8-inch flues spaced equidistant with their open ends protruding at both the retort top and bottom ends. The flues are further fitted with holes at near base locations. The retort in operation requires a short period of burner heating at each flue. After this preheat period, the formed wood gases enter the flue tube holes for combustion and provide the supplementary heat required for completing the coaling action. The operation is described as highly efficient and is currently integrated with briquetting facilities.

The preparation of a newly developed charcoal for barbecuing meats was given patent protection (570). Dry wood blocks for slow burning in grills are prepared by submerging the blocks for 6 to 10 seconds in a cooked starch solution to permit adhesion of a starch layer. The starch layer is top treated with powdered charcoal to complete the processing.

Experiments on the combined distillation of wood tar and wood (169) for the production of a motor oil fraction indicated favorable possibilities as did others (211) for the preparation of a plasticizer from wood tar. Suitable durability of polyvinyl chloride specimens plasticized with birch and pine wood tar oils having boiling points 180° C.+ and 180° to 340° C. (in mixture ratio with 1:1 dibutyl phthalate) was obtained. Some Russian work has been pointed to soluble pitch studies (607) with the development of a scheme for the recovery of compounds contained therein. Supplementary information on the composition and utilization of pitch from pyrolysis and gasification of wood is contained in a review of the subject (592).

Keeping pace with charcoal production emphasis midway in the field between recovery plant and kiln practice has been the continuing establishment of rather small vertical commercial retorts converting singly or by multiunits (564). Operation is more commonly conducted batchwise in the several types of equipment employed. In one unit provision is made for continuous flow of the raw material. All operate similarly in principle by which the wood is converted by recirculation of heated gases. Average charcoal production has been reported at the rate of about 2 tons per day per unit.

Lane in his field studies in kiln production (370) outlines possibilities for more economical designs of charcoal kilns and suggests methods for improvement of production techniques. Results from a number of experimental runs using prescribed operational procedures indicated that good quality domestic charcoal can be consistently produced in kilns. To further determine the place of kilns as an important factor in charcoal production, Boldt and Arbogast conducted a study in which there was integration of kiln production with forest management (86). With efficient operation of a kiln it was demonstrated that it was economically feasible to carry out improvement cutting and cull nonmerchantable material to improve the stand. A chart based on experimental results was prepared and gives data on labor costs, charcoal prices, and wood costs for calculation of the break-even point. An additional recent kiln study carried out in the Philippines made use of mixed species mill waste for charcoal manufacture with subsequent processing to briquettes (423). Briquettes prepared with cassava starch binder were found cheap to produce and had good potential as a substitute material for coke.

The Russians have described a semiindustrial gas plant using mixed wood chips (384a). The process compares favorably with the destructive distillation of wood. A theoretical and experimental study of the pyrolysis of birch chips from 470° to 1273° has been made, and application of the theory to a producer gas plant described (616). The pyrolysis of wood in an electrically heated furnace under nitrogen at 670–80° has been studied (381a), and the effect of variables on the yield of pitch and acids examined.

Wood Hydrolysis

The status of the wood hydrolysis industry in Austria, Switzerland, Sweden, France, Italy, India, and the United States has been reviewed, and the problems of developing a similar industry in Japan analyzed (452a). The Russians have investigated the kinetics of high temperature hydrolysis of spruce wood at 200°–240° (552). With 0.2 percent sulfuric acid, the maximum yield of sugar was 32.8 percent; with 0.1 percent sulfuric acid, the yield was 29 percent. Above 200° the yield of sugars (at 0.4–0.8 percent sulfuric acid) increased from 35 percent to 43 percent. Another semiproduction study of the hydrolysis of wood with sulfuric acid showed that the hydrolyzate could be used to dissolve the mineral apatite yielding a precipitate of calcium sulfate plus phosphoric and hydrofluoric acids (444a). A Russian patent covers pretreatment with phosphate or sodium fluoride to remove iron which promotes degradation of wood sugars (391a), while another deals with hydrolysis with hydrogen chloride at atmospheric pressure (124a). The initial reaction shows only a transient increase in temperature and no degradation of sugars takes place. A Canadian patent (505) covers the saccharification of sawdust via a room temperature prehydrolysis with 29–37 percent hydrochloric acid to remove the hemicelluloses, followed by 40–41 percent hydrochloric acid for the hydrolysis proper.

A Japanese study on the prehydrolysis of hardwood with sulfurous acid showed that lower temperatures and longer times of prehydrolysis were best for maximum furfural production (423a). A United States patent covers the production of hydroxymethylfurfural from sugars such as wood sugars by heating an aqueous solution of the sugars with added furfural to 250°–380° and separating the product in a furfural solution (215a).

Developments in the Chemistry of Lignin

Two recent international conferences have been concerned with various aspects of the chemistry and utilization of lignin. The first was the Fourth International Congress of Biochemistry held in Vienna, Austria in September, 1958. The symposium on the biochemistry of wood contained a number of papers on the chemistry and biochemistry of lignin. These papers have been published as a unit (351), and their contents are included in the present review. The second international meeting, the Fifth World Forestry Congress in Seattle, Washington, August 29—September 10, 1960, included sessions on the chemistry, biochemistry, and utilization of wood. Formal papers presented at this meeting were not published in time to be included in this review and will be included next year.

Kremers (358) critically reviewed the recent literature of lignin chemistry and has drawn attention to the fact that it is marked by renewed interest in lignin biogenesis and is dominated by the premise that spruce lignin is a polymer of coniferyl alcohol and, in large measure, by the assumption that

spruce lignin is a prototype for other lignins. Complete proof for these assumptions is still not at hand.

Model Compound Studies: Model compound studies have continued in some fields of lignin chemistry, but to less an extent than in the past. Gorecki and Pepper (243) synthesized model compounds in the syringyl series, but reported no reactions. Dence and Sarkanen (154) chlorinated lignin model compounds in acid aqueous solution and compared the results obtained with similar chlorination of spruce-wood meal and spruce lignosulfonic acids. Nakano and Schuerch (432) employed ethyl guaiacol and vanillyl alcohol as models for the study of the accessibility of lignin in wood. They studied the reaction with t-butyl hypochlorite in 14 organic liquids of moderate to poor solvent power for isolated lignins. Kratzl and coworkers (353, 355) synthesized the β-guaiacyl ether of guaiacylglycerol and subjected it and other models to several of the well-known reactions of lignin. Results were compared with similar experiments with milled-wood lignin and commercial lignin preparations. These authors found that the guaiacylglycerol β-ether groups of lignin represent the most essential structural element for the most important lignin-degradation reactions such as ethanolysis, acid hydrolysis, alkaline cleavage after sulfonation, alkaline nitrobenzene oxidation, and fission by sodium in liquid ammonia. In addition, these groups appear to be responsible for a large part of the so-called secondary condensations of lignin with phenols. As in the past, other model compound work was in the field of biosynthesis of lignin and/or radioactive tracer studies related to biosynthesis.

Lignification and Biosynthesis of Lignin: An investigation of lignification in model systems was reported by Wardrop and Davies (632) who studied the deposition of so-called eugenol lignin in wood sections of pine, eucalyptus, and basswood. These authors found from staining reactions of lignifying tissues that eugenol lignin, like native lignin, is deposited between cellulose microfibrils in the cell walls. Stafford (583) studied the ligninlike polymers formed by peroxidation of eugenol and of ferulic acid in leaf sections of timothy grass and compared them with the lignin found in mature timothy or hay to find that ferulic acid yields a polymer very similar to the natural product. Siegel, Frost, and Porto (559) found that conversion of eugenol to ligninlike polymers in celery vascular tissue was inhibited by iodoleacetic acid, isonicotinylhydrazine, and mescaline, but was accelerated by quinones. Kratzl and Billek (350) added three model compounds with labeled carbon adjacent to the benzene ring, coniferin, 4-hydroxybenzaldehyde, and 4-hydroxyphenylpyruvic acid, to nutrient solutions into which 2-year-old spruce branches were dipped for 48 hours. Oxidative degradation and ethanolysis reactions of the acid lignins obtained indicated that incorporation of radioactivity was much greater for the coniferin than for the other two compounds. In a study of the role of plant cell-wall polysaccharides in the directed polymerization of 4-hydroxyphenylpropene derivatives to lignins, Goodman and Siegel (239) found that cellulose enhanced the peroxidation of pyrogallol catalyzed by ferric iron.

Higuchi (291) reported results of elaborate studies on the chemical path of formation of the lignin precursors and lignin in plant tissues. These studies included those on the formation of shikimic acid by plants, the formation of lignin building stones, dehydrogenative polymerization of lignin precursors, properties of the phenol oxidase responsible for the dehydrogenative polymerization of coniferyl alcohol, properties of peroxidase-hydrogen peroxide responsible for dehydrogenative polymerization of coniferyl alcohol, coupled oxidation of coniferyl alcohol by yellow enzyme peroxidase systems, the dehydrogenative products of coniferyl alcohol formed by the actions of mushroom phenol oxidase, rhus-laccase, and radish peroxidase, and the formation of lignin from phenylpropanes by plant tissues. Harkin (268) in similar studies treated coniferyl alcohol with mushroom laccase, horseradish peroxidase, and related enzymes and found that on prolonged treatment, the synthesized lignin was degraded with polymerization and degradation reactions proceeding simultaneously.

Fukuzumi (209) isolated an enzyme with laccase activity from the white rot, *Poria subacida.* This enzyme oxidized 4-hydroxy-3-methoxyphenylpyruvic acid with consumption of oxygen and liberation of carbon dioxide and α-hydroxypropiovanillone with only oxygen consumption.

Neish (437) fed a large number of C^{14} labeled compounds to detached leafy twigs of Colorado spruce, and after a metabolic period of 24 hours, isolated the glucoside, pungenin, and determined the specific activities of the glucose and 3,4-dihydroxyacetophenone moieties. He concluded that the phenylethanoid compound was formed by a process involving the loss of the terminal carbon of a phenylpropanoid compound.

Schubert and Acerbo (545) oxidized radioactive lignin isolated from the cambium of Norwegian spruce fed through the needles with D-glucose-1-C^{14} or D-glucose-6-C^{14} and found vanillin labeled primarily in positions 2 and 6. These experiments together with earlier work suggested that lignin is synthesized from glucose *via* shikimic acid and ρ-hydroxyphenylypyruvic acid. In a later paper (2) these authors propose the following scheme for the formation of lignin in plants: carbohydrate $\longrightarrow$ shikimic acid $\longrightarrow$ *p*-hydroxyphenylpyruvic acid $\longrightarrow$ lignin building stones $\longrightarrow$ lignin, and identified the carbohydrate as glucose. Kratzl and Faigle (352) allowed D-glucose-1-C^{14} to diffuse into 2-year-old spruce branches and found radioactivity in all parts of the plant. Radioactive lignin obtained on oxidation, displayed one-third of its activity at the carbonyl carbon, one-sixth each in positions 2 and 6 of the ring and more at the methoxyl. These authors do not agree that the evidence makes glucose a mandatory intermediate in lignin biosynthesis because it does not exclude other sugars as possible lignin precursors.

Nord and Schubert (443) reviewed their work on enzymatically liberated lignin and biosynthesis of lignin, and reiterated the lignification route *via p*-hydroxyphenylpyruvic acid. Harkin (269) took exception to many statements in this review and in particular to the role of *p*-hydroxyphenylpyruvic acid in lignification. Harkin noted that the absolute sequence of these operations has not yet been definitely established; *p*-hydroxyphenylpyruvic acid and ferulic acid may be essential intermediates in these transformations or may merely be transformed independently in side reactions into coniferin or other glucosides. The role of *p*-hydroxyphenylpyruvic acid is rather uncertain, as it has been shown that its incorporation into conifer lignin proceeds rather unsatisfactorily. The Fordham school answered the disputandum by Harkin in the form of a rebuttal by Coscia (269) in which misinterpretations were pointed out, but no change was made in the position. In final reply, Harkin (269) noted that the work of the Fordham school was not at variance with the conception of the Heidelberg school of the biogenesis and constitution of lignin, and it was mainly the *interpretation* which Nord and coworkers give to their results that they could not accept. Although nothing constructive was gained from this polemic, it does point up the fact that the same experimental evidence may be interpreted in more than one manner, and certainly, any investigator should be entitled to draw his own

conclusions from his or anyone else's experimental data.

Nord and Schubert (444) again reviewed their work in this field and summarized their present knowledge of the mechanism of the lignification process by the following enlarged scheme: carbon dioxide → carbohydrate → shikimic acid → *p*-hydroxyphenylpyruvic acid → primary lignin building stones → secondary lignin building stones → lignin. Freudenberg (201) reviewed the biochemical phenomena taking place during wood formation and drew attention to his work on dehydrogenation polymers and the intermediates isolated from dehydrogenation reactions of coniferyl and similar alcohols. In a more comprehensive review, Freudenberg (200) indicated that nine compounds are presently known to play a role in the mechanism of lignification and noted that these known intermediates contain all the structural elements required to explain the chemical behavior of lignin. These compounds are: dehydrodiconiferyl alcohol, aldehyde of dehydrodiconiferyl alcohol, DL-pinoresinol, guaiacylglycerol coniferyl alcohol ether, coniferaldehyde, guaiacylglycerol coniferaldehyde ether, dehydrodipinoresinol, guaiacylglycerol-bis-coniferyl-ether, and guaiacylglycerol - α - dehydrodiconiferyl-β-coniferyl ether. (See figure 1.) The dehydrodiconiferyl aldehyde and guaiacylglycerol coniferaldehyde ether were identified as intermediates in another paper (203).

Billek (75) discussed the techniques used in the Vienna laboratories for the preparation of and administration of labeled compounds and the evaluation of reaction and degradation products. The significance of this work was also discussed.

Shimazono (556) shook surface cultures of *Lentinus lepideus* in which methyl *p*-methoxycinnamate had accumulated and found small amounts of methyl *p*-coumarate and methyl isoferulate during the first and second day. When labeled methyl *p*-coumarate was added to surface cultures, it was converted to methyl *p*-methoxycinnamate presumably by methylation with methionine or a related methylating agent. The occurrence of methyl isoferulate was attributed either to *O*-methylation of methyl caffeate, formed from methyl *p*-coumarate by action of phenolase or by the hydroxylation of methyl *p*-methoxycinnamate by a catalyst other than phenolase.

Wardrop and Bland (631) reviewed the process of lignification in woody plants and described the sequence of changes in the differentiation of wood fibers. These authors determined the ultraviolet absorption spectra of lignin at various levels in the zone of differentiation and described the modification of the lignification process taking place after ring barking and during reaction wood formation. They traced the sequence of changes in the lignification of primary wood, and noted that the observed complementary distribution of peroxidase and lignin deposition supports the view that at least one peroxidase-controlled phase of lignification proceeds within the cell wall. Frey (209) also employed ultraviolet absorption methods to study lignification and lignin distribution in the cell wall of sprucewood and presented evidence to show that lignin is distributed more uniformly over the cell wall and middle lamella than had hitherto been supposed.

Simionescu (562) investigated cankerous wood tissues of many wood species and compared the results with similar results from sound wood. He confirmed the hypothesis that lignification proceeds at the expense of cellulose or cellulose-degradation products such as glucose.

Reznik (503) discussed the physiological relation between lignin and flavonoid formation in wood, and Manskaja (392) reviewed the phylogenesis of lignins. Flaig, Schobinger, and Deuel (194) subjected wheat straw to aerobic decay for 410 days at 28° and analyzed periodically for lignin and humic acids. They concluded that the rotting of wheat straw is accompanied by the conversion of lignin into humic acids. Flaig (193) reviewed the chemistry of humic acids and reiterated the same conclusion.

Kratzl (349), in an excellent summation of the content of the Biochemistry of Wood Symposium of the Fourth International Congress of Biochemistry, critically reviewed and evaluated the several papers noted above.

The Lignin-Carbohydrate Bond: The bond between lignin and carbohydrate in wood received little attention during the past year. Lindberg (379) studied the digestion of wood meal with dimethylsulfoxide at 100° and concluded that real chemical bonds exist between the lignin and carbohydrates in wood. He suggests that the bonding state of the lignin-carbohydrate complex is characterized as a solid solution containing chemical bonds interspersed and embedded in the hydrogen bond network Aaltio (1) studied the extraction of aspenwood meal free of acetone extractives with a neutral buffered butanol-water mixture at 158° From analyses of wood residues and cooking liquors at different stages of the cooks, he hypothesized the presence of ester linkages between the chains of the acidic xylan and lignin. Freĭdin, Malinskiĭ, and Karpov investigated the effects of ionizing radiations from a Co-60 source on the components of the lignin-carbohydrate complex. All components of the complex were degraded, hemicellulose suffering the greatest damage. Radiolysis of carbohydrates consists in their depolymerization and in the destruction of monomeric units. Lignin is partially de-etherified and rendered more soluble. During irradiation of the lignin-carbohydrate complex, lignin protects the polysaccharides from degradation. The aromatic structure of lignin accounts for its greater resistance to radiolysis. Oxidation of the lignin-carbohydrate complex and of its components is a separate phenomenon, not connected with their radiolytic destruction or the presence of oxygen.

Functional and Specific Groups in Lignin: Adler and coworkers have continued their work on structural elements in lignin. Adler and Magnusson (9) studied the action of sodium metaperiodate on many types of phenols and phenol systems as a means for the evaluation of phenolic groups in lignin materials. Adler, Delin, and Lundquist (8) demonstrated that phenyl coumarone systems are formed in spruce milled-wood lignin on treatment with hot acid, and that consequently phenylcoumaran elements were present in the original lignin. An estimation of the frequency of the phenylcoumaran elements indicated that nearly 20 percent of the lignin is made up of phenylcoumaran dimers. Freudenberg and coworkers (207) studied the ring cleavage of 2-phenyl-coumarans and 2-phenyl-tetrahydrofurans by glacial acetic acid-acetic anhydride in the presence of perchloric acid and the introduction of acetyl groups into the cleaved compounds. On the basis of studies on milled-wood, biosynthetic and Brauns' lignins these authors concluded that every third unit of milled-wood and biosynthetic lignin and every fourth or fifth unit of Brauns' lignin possesses a cleavable ether group of the type studied.

Adler (7) reviewed the field of quinoid structures and benzyl alcohol groups in the chemistry and biochemistry of lignin and explained the formation of the biosynthetic lignin intermediates on the basis of such structures.

Gierer, Alfredsson, and Söderberg (227) employed a number of model compounds of the phenylpropanesulfonic acid type to study the cleavage reaction of lignosulfonic acids when treated with a mixture of hydrochloric,

hydriodic, and hypophosphorous acids. Under these conditions one-third to two-thirds of the sulfonic acid groups of lignosulfonic acids are split off rapidly, and the remaining groups are split off slowly. On the basis of their data, these authors conclude that the rapid phase may be due to benzylsulfonic acid groups of the kind which are usually supposed to be present in lignosulfonic acids, whereas the slow phase may be due either to benzylsulfonic acid groups of hitherto unknown types or, more likely, to sulfonic acid groups attached to carbon atoms other than the benzyl group carbons.

Khaĭkina and Vinokurov (333) determined the phenolic and carboxylic group contents of a number of lignins and found that carboxyl groups were found only in technical lignin preparations. They were absent in lignins purified by the cuprammonium method. Both purified and technical lignins contained one phenolic group per molecular weight of 205–215.

Marton (399) employed the sodium borohydride reduction and $\triangle \epsilon$ methods for studying the oxidation states of side chains in native lignin. He found for milled-wood lignin only traces of phenolic coniferyl aldehyde groups, one nonphenolic coniferyl aldehyde group per 30–35 units, one guaiacyl α-ketone group per 200 units and one nonphenolic aryl α-ketone group per 20 units.

Kratzl, Kisser, Graf, and Hofbauer (354) incorporated labeled model compounds into the cambial zone of sprucewood and by degradation and autoradiographic studies demonstrated that guaiacyl compounds must possess a free phenolic hydroxyl group in order to be incorporated. These authors showed that lignifying spruce tissue can synthesize phenylpropane units from physiologically inactive C_6–C_1 compounds, but not to the extent that it does with C_6–C_3 compounds such as coniferin.

Lignin Isolation and Fractionation: A few studies on isolation and fractionation of lignin materials were reported. Pepper, Baylis, and Adler (471) studied the isolation of a lignin fraction from sprucewood and aspenwood meals using a low-temperature (90–95°) acidolysis involving a 9:1 dioxane-water system containing the equivalent of 0.2*N* hydrochloric acid. The effect of extraction time on the yield and methoxyl content of precipitated lignin and ether-soluble material was investigated. These authors suggest that this type of lignin may be only mildly modified during extraction, and hence, suitable for subsequent chemical investigation. Garnett and Merewether (221) subjected eucalyptus wood meal to varying doses of gamma radiation and found that the amounts of lignin and of xylan which could be extracted with ethanol or sodium hydroxide solution increased with the radiation dose. At the maximum dose recorded ($10^{8.5}$ rads) 75 percent of the total lignin was rendered soluble. This increased solubility probably resulted from the cleavage of lignin-carbohydrate linkages by the radiation.

Crude methanol lignin from mature and immature *Eucalyptus regnans* was separated by countercurrent distribution into lignin and degraded lignin by Bland (81). Chromatographic analysis of the separated lignin indicated the presence of several substances with different dissociation constants. The lignin of immature *E. regnans* was shown to possess an empirical formula similar to that of the mature wood. Potentiometric determinations indicated that one in three of the C_9 units was phenolic and ionized in dimethylformamide, whereas spectrophotometric determinations showed one in five to be ionized in methanolic 0.1*N* potassium hydroxide. These determinations suggested that of the phenolic groups ionized in the alkaline methanol, 60 percent are syringyl groups.

Enkvist and Turunen (177) found that commercial vacuum-evaporated calcium-base spent sulfite liquor containing 50 percent solids could be fractionated by a simple extraction technique with hot ethanol into its lignosulfonate and carbohydrate components. The carbohydrates were found largely in the ethanolic extract, whereas the lignosulfonates remained in the aqueous solution. Pearl and Beyer (462) successfully separated the carbohydrate and lignosulfonate fractions of aspen spent sulfite liquors by first decationizing the liquor and then passing it over a regenerated column of Duolite A–2M. Separation data on a number of ion-exchange resins were reported. Boggs and Wiley (85) again described their reactive solvent procedure for the separation of carbohydrate and lignosulfonate components of spent sulfite liquor.

Lignin Analysis: Beketovskiĭ described the use of a qualitative test for lignin based on the development of a yellow-green color upon wetting of lignin-containing material with a solution of cupric nitrate. He employed this test to demonstrate that the lignin complex extracted from aspenwood flour contained free aldehyde groups and guaiacyl residues (60).

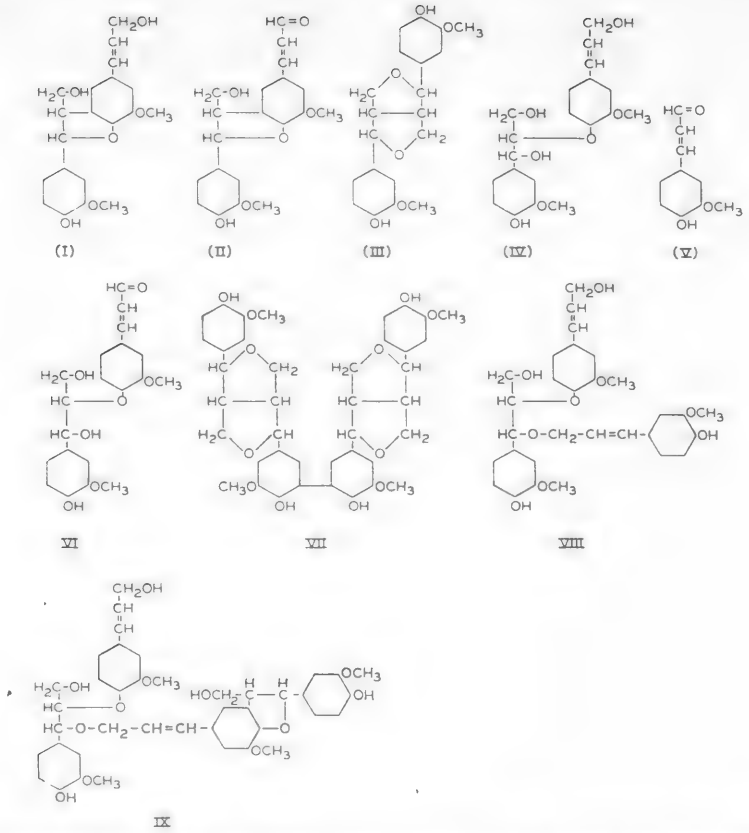
Kühnel (361) showed that certain blue dyes of the triphenylmethane group such as Merck's "Karminazurol" stain lignin-containing fibers, but do not affect lignin-free fibers. He suggests the use of this differential reaction for testing viscose-grade pulps, in which the presence of lignin can lead to filtration difficulties. Bartunek (49) found that the intensity of the yellow color developed by treating wood pulp with warm dilute nitric acid is useful for determining the amount of lignin in the pulp and proposed a spectrophotometric method based on extinction maxima at 261 and 330–338 mμ for this determination.

AUTOMATIC FRACTION COLLECTOR for large scale fractionation of lignin-oxidation products and extractives of spent liquors, woods, and barks. (Institute of Paper Chemistry.)

Busche (109) studied the Klason lignin determination as applied to aspenwood with special reference to acid-soluble lignin. Employing ultraviolet spectroscopy at 208 mμ with aspen milled-wood lignin as a standard this investigator found 2.9 percent of the aspenwood appearing as acid-soluble lignin. This indicated the 15 percent of the original lignin in the aspenwood was solubilized during the Klason lignin determination.

Jayme and Rapp (322) applied their previously described rapid lignin determination employing a mixture of sulfuric and phosphoric acids at 35° to a variety of semichemical pulps and found the method well suited with only slight modifications. The modified method is described in detail.

Goldschmid and Maranville (236) reported an improvement in the determination of spent sulfite liquor by the Pearl–Benson nitrosolignin procedure which provides a filter combination giving more nearly monochromatic light of about 430 mμ for photoelectric colorimetric measurements. This eliminates the undesirable light absorption due to the nitrite reagent and



FRUEDENBERG'S NINE COMPOUNDS presently known to play a role in the mechanism of lignification: I. Dehydrodiconifery alcohol; II. Aldehyde of dehydrodiconiferyl alcohol; III. DL–Pinoresinol; IV. Guaiacylglycerol coniferyl alcohol ether; V. Coniferaldehyde; VI. Guaicylglycerol coniferaldehyde ether; VII. Dehydrodipinoresinol; VIII. Guaiacylglycerol-bis-coniferyl ether; IX. Guaiacylglycerol-a-dehydrodiconiferyl-b-coniferyl ether. (Institute of Paper Chemistry.)

improves both sensitivity and reproducibility.

Employing the lignin: sodium oxide ratio in spent sulfite liquor Ora (451) determined the loss of sodium in sewer water by determining the lignin content of the sewer water.

Kratzl and Puschmann (356) described an elegant method for analysis and small-scale separation of lignin degradation products, especially suited for work with labeled compounds. This method employes "thin-layer" chromatography in which thin layers of absorbing material are coated on glass strips, and these strips are then used in ascending chromatography.

Physical Chemical Studies: The physical chemistry of lignin and its derived materials has received considerable attention. Ultraviolet absorption of lignosulfonates at different pH values were made by Schöning and Johansson (544), and these authors demonstrated that the ultraviolet maximum of spent sulfite liquor at the end of a cook of 205 mμ was due to lignin. Vil'kova (624) studied the luminescence in ultraviolet light of lignins extracted from the stems and bolls of cotton and from wood and found almost identical luminescence spectra for the 480–650 mμ range. This indicates the identity of luminescent centers in lignins of different origins. From the character of the luminescence curves and from the energy distribution in the spectra it appears that the luminescence of both lignin preparations extends into the infrared region.

Hergert (286) determined the infrared spectra of conifer lignin model compounds and degradation products and presented characteristic frequencies for carbonyl groups, ethylenic double bonds, aromatic rings, and hydroxyl groups. He discussed the functional groups occurring in lignin and related these to the mode of isolation. The infrared absorption band of several lignin preparations in the 5.8 μ region were studied by Ekman and Lindberg (170) who interpreted them as being caused by carboxyl groups embedded in a strongly polar medium. Urbanski and coworkers (298) thermally decomposed a commercial lignin and determined the infrared spectra of the products. These investigators noted that the aromatic structure of lignin changed somewhat to a more highly condensed aromatic ring system.

Gardon and Mason (220) separated lignosulfonates from cooking of mixed balsam and spruce by ultrafiltration and fractional dialysis into eight fractions having osmotic molecular weights ranging from 3500 to 58,000. The molecular weight distribution curve indicated the presence of materials with molecular weights as high as 100,000. The higher molecular weight fraction, which contained only sulfonic acidic groups, appeared to be pure lignosulfonates. The lower molecular weight fractions also contained acidic groups other than sulfonic, had lower methoxyl contents, and high reducing powers. Ultraviolet absorption curves indicated the chemical similarity of all fractions. Viscosity, conductivity, and dye adsorption measurements showed that lignosulfonates behave like typical flexible polyelectrolytes. In the presence of sodium chloride, they form compact, water-impermeable coils. Removal of sodium chloride results in loosening the coils. These are indications that the low-molecular fractions associate in solutions, and that the high-molecular fractions are more highly branched.

Goring and coworkers (258, 259, 260) prepared alkali lignin from periodate lignin and studied its physical chemical properties. The alkali lignin was fractionated by means of precipitation with barium chloride into a number of fractions with greatly different intrinsic viscosities. The fractions possessed nearly constant methoxyl contents of 13 percent, visible and ultraviolet absorption spectra, neutralization equivalents and electrophoretic mobilities. Intrinsic viscosities increased at lower ionic strength, indicating that the molecule was a polyelectrolyte. Light-scattering measurements on the fractions indicated a range of molecular weights of 50,000 to 48,000,000. Ultracentrifugal sedimentation of the fractions revealed marked boundary spreading at low and high centrifugal fields. An analysis of the gradient diagrams indicated a wide distribution of sedimentation coefficients. From the log sedimentation coefficient:molecular weight relationship these authors concluded that the configuration of the alkali lignin macromolecule conformed to a structure between that of a random coil and an Einstein sphere impenetrable to solvent.

Meyerhoff (410) employed ultracentrifugation in 9:1 dioxane-water to determine the molecular weight of lignin preparations and found 10,600 for a biosynthetic dehydrogenation polymer, 6700 for a spruce lignin isolated from spruce by cold acetone extraction, and 6300 for a milled-wood lignin from spruce.

Odintsov (445) studied the swelling of lignin in various solvents and under a variety of experimental conditions. He found that lignin in the form of lumps or thin sheets, swells in water and organic solvents considerably more than was indicated in the literature. In water the swelling of lignin is only slightly less than that of cellulose. Lignin obtained by the hydrolysis of wood with concentrated sulfuric acid swells in the acid to a volume exceeding that of the initial wood, and swells more in the tangential than in the radial direction. Lignin obtained by the action of dilute sulfuric acid at high temperature and dried occupies a smaller volume than lignin obtained by the concentrated acid method. This apparently results from the tendency of the lignin particles towards orientation and dense arrangement during drying. Lignin swells strongly in concentrated sulfuric acid, but the presence of sugars in the acid reduces the swelling. It swells less lengthwise than crosswise, a phenomenon which indicates the possibility of a certain degree of orientation of the lignin molecules along the axis of the wood fibers. Christensen and Kelsey (134) measured the swelling during water-vapor adsorption of samples of Klason and methanol lignin from eucalyptus by compressing the lignin into small blocks and exposing these blocks to successive changes in relative humidity. By making some simple assumptions, these authors were able to distinguish between the water which entered the lignin structure to cause swelling and that deposited in existing void spaces without causing swelling. The results demonstrated that during sorption of water vapor, lignin behaves predominantly as a swelling gel, rather than as a rigid porous adsorbent.

Kanda and Kawakami (328) compared the polarographic behavior of several fractions of kraft lignins from extracted pinewood with Brauns', ethanol, and dioxane lignins of pine and found that the catalytic wave heights of ethanol and dioxane lignins were generally lower than the alkali lignins, but increased somewhat when these lignins were treated with hot alkali. This indicated that severe changes in the lignin structure caused by hot alkaline treatment are closely connected with and reflected by increased polarographic activity.

Gaslini and Nahum (222) compared two conductometric methods for titrating alkali lignin preparations. The first, in which the lignin was dissolved in excess aqueous sodium hydroxide and back-titrated with hydrochloric acid, gave results similar to those obtained with previously reported conductometric titrations of alkali lignins. The second, in which the lignin was dissolved in aqueous lithium metaborate and then titrated with lithium hydroxide, gave total acidity values higher than other methods and showed two equivalence points corresponding to acidic groups of different strength.

Umano and Kawasaki (617, 618) concentrated spent sulfite liquor by freezing to about 43 percent solids and tested the concentrated liquor for chemical composition, density, viscosity, and freezing point. The calcium, methoxyl, and total sulfur contents were found to become concentrated in exact proportion to the total extent of concentration. The effect of a silicone foam inhibitor on freeze-concentrated spent sulfite liquors was studied. Foaming tendency increased with progressive concentration, but the durability of the foam diminished. The foam inhibitor was effective at low degrees of concentration, but relatively large amounts were required to check foaming in highly concentrated liquors.

Chemical Properties: A review of the present knowledge of hardwood lignins with particular emphasis on those aspects of hardwood lignin chemistry requiring further research was made by Pepper (470).

Nakana and coworkers (431) studied the original Mäule reaction for distinguishing hardwoods and softwoods on several synthetic lignins and demonstrated that the mechanism of the Mäule reaction is different from the more commonly employed Cross and Bevan (chlorine plus sodium sulfite) color reaction.

Changes in the visible and ultraviolet absorption spectrum of lignin were studied by Ivancic and Rydholm (316) under conditions simulating technically important processes such as acid condensation, oxidation, reduction, pH changes, chlorination, and alkali treatment. Color formation was attributed to phenolic, carbonyl (or condensed carbonyl), and sometimes condensed imino groups. Spectral changes observed were interpreted in terms of a possible reaction mechanism for the chlorination of lignin and the alkalization of chlorolignin.

Skrigan and Murashkevich (567) studied the chemical composition and functional group content of fossil pinewood with those of fresh pinewood and found that methoxyl group content decreases with age. Siegel, LeFevre, and Borchardt (560) compared the ultraviolet absorption of fossilized plants with related living species and found that the fossil plant extractives contained fewer ultraviolet-absorbing components. The fossil forms lacked components absorbing beyond 300 mμ, indicating a loss of aromatic ligninlike substances. Thermal treatment of isolated pinewood lignin and pine sawdust resulted in an over-all reduction of ultraviolet absorption, in the shifting and disappearance of characteristic absorption peaks, and in insolubilization of lignin, attributable to cross-linking with the formation of high molecular weight polymers. These authors suggest the possible use of lignin solubility and ultraviolet absorption as indicators of the thermal history of regions containing fossilized plant residues.

Skrigan, Murashkevich, and Kozlov (568) investigated the thermal degradation of hydrolysis lignin from aspen and pine and described a plant-scale operation. They found that under industrial conditions one ton of lignin would yield 40 kg. phenols, 20 kg. light oils, 250–280 kg. activated carbon, and 300–400 cubic meters of high-caloric value gas suitable for heating purposes.

Swensen (596) describes an ion-exchange process for removing cations from spent sulfite liquor in which the produced lignosulfonic acids are employed for regeneration of the exchange resins to the hydrogen form.

Ishikawa (312) studied the structure of lignin in relation to the phenolatable and sulfonatable groups and found that phenol condenses with lignin through its *o*- or *p*- position. Matsugu and Shiraiwa (402), in continuing their studies on water hydrolysis of wood, found that phenolic hydroxyl groups remain constant during softwood hydrolysis, but increase during the early stages of hardwood hydrolysis. Experiments were also carried out on hydrolysis during kraft and sulfite cooking.

Sosnin (579) found that heating of birchwood and sprucewood shavings with 3–4 percent nitric acid results in the oxidation and solubilization of 87–95 percent of the lignin. Under similar conditions, isolated oak lignin and pine lignin were oxidized only to the extent of 24–25 percent and 7–8 percent, respectively. Removal of the hot water-soluble extractives of oak and pine resulted in oxidation of 57–61 percent of the lignins in these woods. Addition of these same hot water-soluble extractives to birchwood lignin gave marked inhibition of oxidation.

Pearl and Beyer (463) oxidized an aspen-derived spent sulfite liquor with both alkaline silver oxide and alkaline cupric oxide. In addition to the expected vanillin, syringaldehyde, vanillic acid, syringic acid, *p*-hydroxyben-

zoic acid acetovanillone, and acetosyringone, these authors found ferulic and *p*-coumaric acids. This is the first recorded instance of the obtainment of lignin-degradation products containing three-carbon side chains from lignin oxidation reactions. Tanaka and Kondo (600) identified 4,4'-dihydroxy-3,3'-dimethoxystilbene and 2,6-dimethoxyphenol in the alkaline oxidation products of beechwood lignin.

Kishimoto and coworkers (338) compared charcoals prepared from wood hydrolysis lignin and dioxane-hydrochloric acid lignin by wet oxidation with phosphoric-chromic acid mixture and observed differences in degree of oxidation. Comparison of both lignin charcoals with wood charcoal indicated that water-soluble materials from the carbonization of carbohydrates in wood greatly affect the oxidation of wood charcoal.

Holmberg (301, 302, 303) has prepared a number of sulfur-containing products by treating various sprucewood lignin preparations with thioglycolic acid, thiobenzhydrazide, and related reagents, and has reported qualitative and quantitative analytical data.

Lindberg (378) prepared thiolignin by cooking sprucewood with sodium hydrosulfide at 100° and obtained sulfur-containing catechol derivatives from the water- and ether-soluble portions. Doughty and Cook (162) precipitated chlorinated lignins from alkaline extractions in pulp bleaching systems by means of aluminum sulfate.

Polcin (478, 479) described a process for the chlorination of alkali lignin in aqueous or organic medium. Products containing as high as 25 percent organic chlorine are produced in aqueous medium, and as high as 30 percent chlorine in methanolic medium. Chlorine is introduced into the lignin by both substitution and addition. Experiments indicate that in aqueous medium, methoxyls are split from aromatic rings, and in nonaqueous medium, methoxyls are split from the side chains.

Giesen (229) described a continuous noncatalytic hydrogenation process for the decomposition of Scholler lignin into distillable products by employing pressures above 350 atmospheres and temperatures above 300° C.

Kusumoto (363) compared the tanning properties of red pine spent sulfite liquor with vegetable tannins and found that the tannin of the spent liquor was absorbed preferentially by hides from mixtures of spent liquor and vegetable tannins.

Lignin Utilization: Papers and patents on the utilization of lignin and lignin-containing materials accounted for a large share of the literature appearing during the year in the field of lignin. A number of review articles on various aspects of the utilization of spent sulfite liquor and lignosulfonates (25, 299, 530, 625, 643) and one on lignin itself (183) appeared.

Borisek (87, 88) described a process for the isolation of a reactive lignin from spent sulfite liquor by treating with ammonia under pressure at temperatures above 100° C. and precipitating with mineral acid. The author suggests this product for all the uses previously known for lignosulfonate materials. Gardon and Leopold (217, 218, 219) describe processes for the production of reactive lignin materials and infusible and partially or completely alkali-soluble lignins of high carbon contents by treatment of spent sulfite liquor with excess lime at high temperatures. Gray and Crosby (251) prepared a high molecular weight calcium lignosulfonate by slurrying a precipitated basic calcium lignosulfonate in water and contacting with an ion-exchange resin of the free carboxylic acid type.

Several Soviet investigators have reported on the preparation of active carbons from hydrolysis lignin (181, 474) and spent sulfite liquor lignins (151).

The physical properties of lignosulfonates, lignins, and liquors containing these have been utilized in many reported processes. Lignosulfonates in the molecular weight range of 10,000 to 40,000 have been shown to be the best dispersing agents as measured by viscosity reduction of titanium dioxide particles. Byrd (112, 113) described the preparation of a good dispersant for solid-in-liquid suspensions by reacting concentrated oxidized sodium-base spent sulfite liquor with sodium or potassium dichromate. The use of lignosulfonates and spent sulfite liquor as a dispersing agent for and component in hydraulic and Portland cements (62, 63, 492, 594, 651) and as a dispersant in agricultural spray and fungicidal compositions (58, 195, 640) has been noted. Lignosulfonates have been proposed for dispersing vat dyes and color emulsions for textile dyeing (100, 626). Considerable attention has been given to the use of lignosulfonates, spent sulfite liquors, and lignin preparations in well-drilling mud compositions (101, 283, 336, 523, 580, 606, 636, 649). Drilling mud additives with special properties were described by King and Adolphson (337) who treated spent sulfite liquor with iron sulfate, aluminum sulfate, chromium sulfate, or copper sulfate so as to form the appropriate metal lignosulfonate, and then oxidizing the salt with a chemical oxidizing agent or by electrolysis.

Many patents were issued for the use of lignin in the rubber industry in lignin-rubber mixtures (160, 254, 414, 415, 574), lignin-rubber coprecipitates (281) lignin-rubber master batches (280) and butadiene-acrylonitrile rubbers (161).

Lignosulfonates have been mixed with coal dust, fly ash, and other pulverulent materials to decrease their tendency to become airborne during processing (273). Wood lignin was employed in compounding a cement for carbon bricks (110) and in making a shell mold from sand (140) Spent sulfite liquor and lignosulfonates have been employed in the preparation of adhesives for laminating paper and board (376, 619), for plywood and wallboard (620, 621), and for floor and wall coverings (16). Purified alkali lignins have been used for the preparation of phenol-lignin-formaldehyde resins (577).

Lignosulfonates have been employed for road surfacing (198), feedstuffs for animals (5, 6), corrosion inhibitors (107), and tanning agents (397, 406).

Lignin-containing spent liquors have been employed as starting materials for the production of organic chemicals. The Crown–Zellerbach group has continued research in the field of sulfur chemicals. Goheen and coworkers have described a process for the production of methyl mercaptan from alkali lignin (232) and from desugared spent sulfite liquor (233) and of dimethyl sulfide from black liquor or sodium-base spent sulfite liquor (135) and from disugared spent sulfite liquor (234, 235). The large plant of Crown–Zellerbach at Bogalusa, La., for the production of dimethyl sulfoxide, dimethyl sulfide, and methyl cercaptan was described (31).

Pearl (461) described a procedure for the isolation of *p*-hydroxybenzoic acid from spent pulping liquors of aspen origin, and showed that yields of *p*-hydroxybenzoic acid from acid liquors could be enhanced by mild alkaline hydrolysis.

Tachi and Murakami (597) prepared polymers of vanillin derivatives containing urethane, aminocarbonate, and amide linkages in an attempt to develop a large-scale utilization of lignin-derived vanillin. These same authors (427) polymerized the hydroxyethyl ether of vanillic acid and studied the thermal stability of the polymer as a function of the molecular weight. Kamlet (327) described a

process for the production of gallic acid from halogenated lignin vanillin.

In a study to determine whether new chemicals could be obtained from spent pulping liquors, Enkvist (176) heated concentrated spent sulfite liquor or sulfate black liquor continuously or periodically with sodium sulfide and sodium hydroxide and obtained up to 50 percent (organic matter basis) of ether-soluble substances including degradation products of both lignin and carbohydrates. Identified compounds included pyrocatechol, 4-acetopyrocatechol, protocatechualdehyde, and protocatechuic acid.

Bark

A number of interesting developments have been reported since last year's review (467). Two quite good general reviews have appeared (248, 539), and a Finnish editorial discussed the "Bark Problem" (38). The Institute of Paper Chemistry has issued a very thorough bibliography on debarking (513). The use of bark as a fuel has received further attention (557, 566), and the briquetting of spruce and pine bark has been shown to be quite advantageous (417).

The possibility of using bark and other wood waste as an animal litter and/or soil amendment has received further attention (61, 196). For a soil conditioner, bark composted with added mineral nutrients appears to be promising (642). An article in the first issue of a new journal, *Compost Science,* discusses composting wood wastes with other organic materials which furnish the necessary nitrogen (225). Ammoniated Douglas-fir bark has been evaluated (45), and Bollen and Glennie presented an excellent paper at the Wood Industries Conference held in Portland, September 10–12, 1959, on the use of wood waste, including bark, in and on the soil.

The effect of incorporating bark from a number of hardwood and softwood species into hardboards has been extensively studied (19, 428). The bark of willow, pine, and cork oak may be used in insulation and in molded articles (326). *Eucalyptus crebra* bark has been used in building boards (104), and Douglas-fir bark has been made into composition boards without using any additives (108). The use of cork and parenchyma fractions from conifer bark as a thermoplastic adhesive in hot-pressed hardboards has been patented (288). The production of cork from the bark of *Kielmeyera coriacea* (644), *Quercus pseudo-cerris* (332), *Q. suber* and *Phellodendron amurense* (485) has been discussed, and a patent has been issued on the production of cork from Douglas-fir bark (137). A new method for producing cork from bark such as Douglas-fir involves exploding the bark in a masonite gun (59). Additional patents have been issued on methods for obtaining fibers from bark (263), and on the use of redwood bark fibers in air filters (362, 377).

Interest in the use of bark products in oil well-drilling muds has remained high. A number of Canadian patents have been issued involving the use of western hemlock bark extracts (82, 101, 605, 636). The use of bark polyphenolics has been discussed (26), and a review article deals with polyphenols and bark fiber products in oil well-drilling muds (413). Bark polyphenols have also shown considerable promise in resins and adhesives. HT–120 from western hemlock bark can be used in low-cost cold-setting adhesives, and other western hemlock bark extracts can be used in resin formulations (22, 252, 290). Douglas-fir bark can also be used in making an adhesive extender (486, 645), as well as for the production of phenolics and waxes (289, 657). Most of these applications involve patents which include other barks in addition to the main species investigated. A patent has been issued on the countercurrent extraction of Douglas-fir and other barks (508). Tannin-containing barks such as Douglas-fir or hemlock may be condensed with formaldehyde to produce ion-exchange resins (385). The use of alkaline extracts of tree barks (i.e. pine) for tanning has also been patented (76).

The polyuronides of aqueous bark extracts have been studied (346), as has the xylan from the bark of *Edgworthia papirifera* (13). The polysaccharides of *Picea glauca* inner bark contain considerable pectic material, starch and a xylan free from 4–O–methylglucuronic acid residues (457). The polysaccharides of the inner bark of paper birch have been examined and shown to consist of approximately equal amounts of cellulose and 4–O–methylglucuronoxylan plus a small amount of pectic acid (arabino-α-D-galacturonic acid) (411). A resin suitable for a shellac substitute has been prepared by chemical treatment of birch bark (334). The lignin from the outer bark of *Quercus crispula* has been studied (277). The production of gutta percha from *Euonymus* spp. bark has been discussed (590). A number of Congo tree barks have been analyzed for ash, tannins, alkaloids, and ether-extractables (314).

Extractives of Wood and Bark

Among the general papers on extractives that have been published (68), that by Anderson at the 5th

CO-AUTHOR JOHN ROWE, U. S. Forest Products Laboratory, prepares an extraction of chemicals from bark by percolation with cold solvent.

World Forestry Congress in Seattle, August 27–September 10, 1960, entitled, "Biochemistry of Wood Extractives," deserves special mention. An FAO review was devoted to the subject of "Progress in the Chemistry of Wood Extractives" (538). The technical papers of the Wood Industries Conference held in Portland, September 10–12, 1959, contain several items of interest. Creighton discussed the phenols of western redcedar and, especially, the utilization of plicatic acid as an antioxidant and as a chelating agent. Van Blaricom had a very interesting discussion on the derivation of organic chemicals from wood and bark. An international symposium on the chemistry of natural products was held under the auspices of the International Union of Pure and Applied Chemistry in Australia, August 15–25, 1960.

A recent volume on natural products (656) contains an excellent chapter by Venkataraman on flavones and isoflavones covering proof of structure, color tests, chemistry, synthesis and biosynthesis, and including tables of occurrence and of infrared and ultraviolet spectra. Another chapter by Barkemeyer and Korte surveys bitter principles, while Bernauer has a chapter on the *Strychnos* spp. alkaloids. A new annual entitled, "Chromatographic Reviews," (375) promises to contain much of interest to extractives chemists. Vol. 1 contains Reio's excellent paper on the paper chromatography of many phenolic derivatives, a chapter by Marini–Bettolo and Casinovi on *Strychnos* spp. alkaloids, another by Harborne on the paper chromatographic identification of anthocyanins, one by Neher on steroids, and another by Sestak on chloroplast

FPL TECHNOLOGIST prepares an anhydrous distillation.

pigments. Volume 2 contains a chapter by Harborne on flavonoid pigments. Wall has published the latest in his series of surveys (630) covering 921 species in 547 genera, many of them trees. Sterols, tannins, alkaloids, and flavonoids are reported. An extensive phytochemical register of Australian plants lists many extractive constituents (555). Excellent indexes and toxicity data are included. Another review on conifer chemistry and taxonomy has appeared (179), and the Swedish group is continuing its work on conifer heartwood extractives.

A number of developments have been reported during the past year involving *Pinus* spp. The changes in *P. densiflora* resin during pulping have been studied (442). *P. pinaster* resin has been shown to contain resin acids, wax acids, sitosterol and 7-dehydrositosterol (155); a leucocyanidol from the bark that precipitates blood lipoproteins was also studied (602). The water-soluble polysaccharides, especially arabogalactans, from Pinaceae have been studied (93), and the free mono- and oligosaccharides of various parts of California softwoods examined (572). A method has been described for distinguishing *P. pinea* and *P. halepensis* via their extractives (495). A new tertiary alcohol, abienol, has been isolated in a 5 percent yield from pine rosin (472). The fragrance of pines has been discussed in a very interesting article by Mirov (419). Continued interest is being shown in the tannins from *P. radiata* bark (307), and the production of a satisfactory flakeboard adhesive has been described (264). For this, bark extracts were superior to bark powder.

In a study of *P. banksiana* bark (518), it has been found that the benzene extract contains lignoceryl alcohol, free and combined lignoceric acid, sterols, resin acids, lignoceryl ferulate, pinosylvin dimethyl ether, a trace of paraffin hydrocarbons, and a new triterpene, dihydroxypinusene. This triterpene contains a double bond and two hydroxyl groups on a new pentacyclic skeleton. Subsequent extraction of the bark with ether yielded quercetin, 6-methylquercetin, 6-methylmyricetin, dihydroquercetin, dihydromyricetin, catechol, vanillin, and other compounds. The bark of *P. monticola* is also under study (518).

Although it is not the purpose of this review to cover the voluminous literature on tall oil, the fact is that the constituents of tall oil by and large represent extractives that were originally present in the wood (usually pine). Therefore, a few leading references to recent developments and reviews would indeed be appropriate. High molecular weight fatty acids and heptadecanoic acid have been found in the tall oil from *P. radiata* (139). The chromatography of pinewood and tall oil fatty acids on magnetite has been investigated (325). The two latest tall oil bulletins are entitled, "Tall Oil in Synthetic Detergents," and "Fatty Acids from Tall Oil" (28). The use of tall oil in synthetic detergents has been reviewed (491), as has the isolation of sterols from tall oil (12, 434). Tall oil and a rosin-free resin derived from pinewood can be used in oil well-drilling fluids (149). A continuous tall oil recovery process has been described, and the chemistry and industrial utilization of tall oil discussed (11, 54, 591). The estimation of tall oil in sulfate black liquor has also been investigated (529). Statistical and market data have been published (581, 627).

The main recent interest in *Picea* spp. has concerned the tannins from the bark, usually of *P. abies (excelsa)* (77, 409, 587, 658). Sulfited spruce tannins have also been of interest (174). Polyuronides, robinetin and quercetin have been found in the aqueous extracts of *P. abies* bark (347). A galactan has been isolated from the compression wood of this species (91). *P. omorica* wood has been found to contain fatty acids, wax alcohols, sitosterol, and two tannin glucosides containing a C–18 aglucone (152). Geochemical prospecting, analyzing several parts of spruce for minerals, has been tried (512). *P. mariana* inner bark contains appreciable amounts of 3',4',5,7-tetrahydroxyflavan-3,4-diol as well as 3,4'-dihydroxy-3'-methoxystilbene-5-O-β-D-glucoside and catechin (394). A survey has been made of the polyhydroxystilbene condensed tannins in this genus (249). A number of lignans have been isolated from the callus resin of *P. abies* (635).

The wax from the barks of *P. jezoensis* and *Abies mayriana* was shown to consist of wax alcohols, wax acids and sterols (276). Tannin was also isolated from the former and from *A. pectinata* bark (587). *A. sibirica* resin has been shown to contain abietic acid, neoabietic acid and abietyl alcohol (310), and the commercial utilization of fir oleoresin was discussed (558). The method for producing conidendrin as a byproduct of pulping *Tsuga heterophylla* has been patented (575).

A number of interesting developments have been reported in the Cupressaceae. The chemical utilization of *Thuja plicata* wood and bark has been discussed (639), and the use of plicatic acid in electroplating baths patented (614). It has been found that β-thujaplicinol contributes only in a minor degree to the durability of this heartwood (510). Pharmacological tests are being made on these thujaplicins and polyphenols (35, 265). Cupressaceae tropolones have been characterized as their dicyclohexylamine salts (655), and two new tropolones, pygmaein and α-thujaplicinol, have been isolated from *Cupressus pygmaea* heartwood (654). A variety of interesting mono- and sesquiterpenoids have been isolated during thorough examinations of the heartwood constituents of *Chamaecyparis thyoides* (178), *Juniperus chinensis* and *J. utahensis* (522). A new compound, utahn, was isolated from the last. Thujopsene has been shown to be identical with widdrene and widdrenic acid identical with hinokiic acid, and the structures of these sesquiterpenoids were elucidated (180, 342, 565). In addition, longifolene was shown to be identical with kuromatsuene and junipene, while juniperol was identical to kuromatsuol, longiborneol and macrocarpol (15). The complete structures of hinokiol and hinokione from *Chamaecyparis obtusa* and *Tetraclinis articulata* have been determined (133). L-arabinoic acid was isolated from the heartwood of *Libocedrus (Austrocedrus) chilensis* (46). A new sesquiterpene, occidol, has been isolated from the essential oil of *Thuja occidentalis* (296), and the essential oils of *Juniperus phoenicea* (145) and *J. virginiana* (318) have been studied. The wood oils of *J. virginiana* and *Cedrus deodara* have been compared (132).

Waxes containing wax alcohol esters of ferulic acid have been isolated from *Phyllocladus glaucus* bark (99). This type of compound is probably fairly common. Eicosanyl ferulate is

found in the heartwood of *Larix laricina* and esters of ferulic acid are also found in *L. lyalii* heartwood (430). The extractives of these two species were thoroughly studied. Taxifolin and aromadendrin were major constituents, and both appeared to possess what might be an ester of phthalic acid with β-sitosterol and nonan-2-ol–reminiscent of the very unusual analogous ester found in *Picea sitchensis* (467). Unsaturated fatty and wax acids as well as numerous other compounds were also isolated, but no resin acids or tropolones. Extractives of *Larix decidua* wood were also studied and dihydroquercetin, dihydrokaempferol, liovil and a new lignan, seco-solariciresinol, identified (205). The distribution of dihydroquercetin in *L. occidentalis* and *Pseudotsuga menziesii* was investigated (216). However, most recent interest in *Larix* spp. has concerned the water-soluble arabogalactans (4, 44, 90, 613). Dimethoxy-isolariciresinol has been found in *Alnus glutinosa* wood (205), while the photometric determination of anthraquinones in the bark was investigated (459).

Podocarpus spp. have received considerable recent attention. The essential oil of *P. spicatus* has been analyzed (386), and its heartwood extensively investigated (96). In addition to flavanoids, isoflavanoids, inositols and lignans, the structure of a new lignan, seco-isolariciresinol, was determined. This lignin was also found in *Larix decidua* as mentioned in the previous paragraph. A phenolic acid has been isolated from *Podocarpus macrophyllus* wood (23, 599), and *P. dacrydioides* heartwood has been found to contain large amounts of podocarpic acid, its methyl ester, ferruginol, 9–dehydroferruginol, sugiol and a new resin acid, pododacric acid (98). The artifact, xanthoperol, previously found in *Juniperus communis,* was also found, and additional work has been carried out on the chemistry of this compound (94). Total syntheses of *d*-podocarpic acid, ferruginol and sugiol have been achieved (226, 638). The bled resin of *Podocarpus ferrugineus* has been found to contain ferruginol, and the miropinic and isomiropinic acids have been shown to be isopimaric acid and sugiol respectively (95). Isopimaric acid was also found in *Dacrydium biforme* and *D. kirkii. D. cupressinum* bark has been found to contain totarol, sitosterol, sequoyitol and a new leucocyanidin (118). *Cryptomeria japonica* heartwood and resin have been investigated and found to contain the artifact, xanthoperol, and sugiol, ferruginyl acetate, 9-dehydroferruginyl acetate, sitosterol, isopimaric acid, and a new diterpene alcohol, phyllocladanol (343).

A major class of interesting and important tree extractives are the alkaloids. Many recent reports cover the discovery of both new and known alkaloids, as well as structural and synthetic studies in such species as *Conopharyngia durissima* bark (502), *Ceanothus* spp. bark (511), *Erthroxylum coca* (282). *Hortia arborea* (455), *Erythrophleum* spp. barks (43, 175), *Enantia chlorantha* bark (548), *E. polycarpa* bark (111), *Geissospermum* spp. (67, 490, 497), *Hunteria eburnea* bark (48), *Michelia* spp. barks (315), *Pausinystalia yohimbe (Corynanthe johimbe)* bark (460), *Quillaja saponaria* bark (148), *Tabernanthe iboga* (438), *Tabernaemontana* and *Ervatamia* spp. (244), *Voacanga africana* bark (501), *V. dregei* bark (439) and *Vallesia dichotoma* (300). Two supplementary volumes of Manske's "The Alkaloids" (393) brings this important series covering all of the alkaloids up to date. Also of interest is a recent volume on the optical rotatory power of alkaloids which lists the known alkaloids (401). A thorough survey of the alkaloids of the Aponynaceae with taxonomic correlations has been published (493). Another paper deals with the paper chromatographic analysis of 70 alkaloids (629). The biogenesis of alkaloids has been recently reviewed (197).

Aspidosperma spp. have received considerable recent attention. Alkaloids, including new ones, have been found in several additional species (40, 450, 543). The structures of olivacine, quatambuine, u-alkaloid C, u-alkaloid D and palosine (450, 543), as well as of aspidospermine (416) and quebrachamine (341) have been determined. The biogenesis of aspidospermine has also been discussed (509).

As predicted last year (467), *Lunasia quercifolia* bark has been found to contain among its alkaloids the compound, lunasine, which is the optical antipode of deoxy-4-0-methylbalfourodinium salt (487). A good review of *Lunasia* alkaloids has appeared (241), and the alkaloids of *L. amara* bark have been further studied (69). The alkaloids of *Balfourodendron riedelianum* bark have also been more thoroughly studied and a new alkaloid, isobalfourodine, was found (496).

The effect of ultrasonics on *Cinchona* bark alkaloids has been studied (3), as has the use of these alkaloids in the synthesis of potential amoebicides (483). New alkaloids have been isolated from *Strychnos toxifera* bark (53), and the field of *Strychnos* alkaloids thoroughly reviewed (65, 330, 375, 656). Further progress has been made on the structure elucidation of the diterpenoid insecticidal alkaloid, ryanodine, from *Ryania speciosa* (47). Alkaloids and other interesting compounds have been isolated from the leaves, wood and bark of *Flindersia xanthoxyla* (506) and *F. bennettiana* (213a), and the structures of maculosidine and maculosine from *F. maculosa* have been determined (484). The resistance of a number of species to marine borers was shown to be due to the presence of silica or alkaloids (166). From *Liriodendron tulipifera* heartwood there has been isolated a new yellow nitrogen-containing pigment, liriodenine (105). Citral, ellagic acid and furoquinoline alkaloids were isolated from *Phebalium nudum* wood (115). The structure of pithecolobine from the bark of *Pithecellobium saman* has been elucidated and found to contain an unusual macroheterocyclic ring (641). *Erythrina indica* bark was investigated and found to contain docosyl alcohol, a series of sitosterols, triterpenes, alkaloids and other compounds (70). The stereochemistry of erythrinane derived from erythrina alkaloids was determined, and syntheses made (422).

High interest in the steroidal alkaloids from *Holarrhena* spp. has continued. Further species have been investigated (72, 320), the structure of holarrhenin was determined (305), dihydroconessine has been synthesized (143), and considerable attention was paid to the conversion of these alkaloids into pharmaceutically active sterols (364, 458). It has also been observed that bark extracts from *H. antidysenterica* and *Alstonia scholaris* induce tumors in onions (553). A review of *Alstonia* spp. alkaloids and their effect on high blood pressure has been published (171), and the alkaloids of *A. muelleriana* investigated (230). The structure of echitamine, the major alkaloid of *A. scholaris,* has been the subject of considerable disagreement (123, 127, 138), and the true structure is probably still not known (78). *Fagara (Zanthoxylum)* spp. have been the subject of much recent interest. *R. rhetsa* bark has yielded lupeol and a series of alkaloids (126, 521). *F. avicennae* has yielded hesperidin, diosmin, avicennin and a new alkaloid, avicine (42). *F. nitidum* (42) and *F. coco* (331) alkaloids were also studied, and a number of structure proofs and syntheses have been carried out (42, 242, 456). F. *ailanthoides* wood yields sitosterol and methoxycoumarins (274, 598), while lupeol and sesamin have been isolated from *F. rhoeifolia* bark (41). Steroidal alkaloids of a different type have been isolated from *Funtumia africana* and *F. latifolia* (321).

Steroidal sapogenins have been isolated from *Yucca brevifolia* (652). The sapogenin from *Fouquieria peninsularis* bark saponin has been shown to be echinocystic acid (231). A spasmotic and hypotensive principle has been isolated from *Viburnum opulus* bark (500). The pharmacologically active constituents of *Piper methysticum* have received considerable recent attention (106, 120, 340, 541). Its kava resin is rich in unusual α–pyrones, and a number of other compounds have also been isolated including alkaloids. *Aniba* is another species which contains α–pyrones as well as cotoin and an alkaloid in the wood and bark (424). The wood and bark of *A. canelilla* and *Ocotea pretiosa* contain eugenol, methyleugenol and an unusual compound with a strong cinnamon odor and flavor (246). This compound was found to be 1-nitro-2-phenylethane, the first time a natural product has been found with a nitro group as the sole functional substituent. Alkaloids were investigated in *O. (Nectandra) rodiaei* (256, 536) and *O. leucoxylon* (240). The low rate of moisture absorption of *O. rubra* wood and its incompatibility with PF glues have been correlated with its extractives (604).

From *Simaruba amara* bark (481) there has been isolated a new bitter principle, simarolide, as well as the yellow pigment, 2, 6-dimethoxybenzoquinone, which has been found also in *Picrasma crenata* wood and *Khaya senegalensis* bark (482). Partial structures were also elucidated for the bitter principle, obacunone, from *Phellodendron amurense* bark and *Casimiroa edulis* seeds (360), as well as for nimbin from *Azadirachta integrifoliola (Melia azadiracta)* bark (550). The bitter principles simarolide, obacunone and nimbin all appear to have furanotriterpenoid structures similar to limonin. *A. integrifoliola* bark has been further investigated (550), and nimbiol synthesized (73, 165, 190, 637, 638). *Melia azedarach* bark has been found to contain catechol and vanillic acid, of which the latter was responsible for the bark's anthelmintic action (447). The bitter principle, quassin, from *Quassia amara* wood appears to possess an unusual diterpenoid structure (622). An unusual new compound, oleuropeic acid, has been isolated from *Olea europaea* (554). This and protocatechuic acid esterified with glucose form the bitter principle, oleoropein.

The chemical and pharmacological properties of *Rhamnus frangula* and *R. purshiana* barks have been further studied and barbaloin has been isolated (55, 150, 187). The spectrophotometric determination of the anthracene derivatives in these barks was investigated (381). The structures of α- and β-sorigenin from R. *japonica* bark were verified by synthesis (304). *R. pallasii* bark has been found to contain anthraglucosides, saponins and resinous and tannin substances (10). An extensive review on the antimicrobial activity of vascular plants includes references to many tree species (441), as does a recent book entitled, "Phenolics in Plants in Health and Disease," (488). A crystalline antibiotic has been isolated from *Tabebuia wood* (237), and the antibiotic properties of some *Mesua ferrea* constituents have been studied (122). A toxic extract was prepared from *Ailanthus altissima* (407). Pharmacologically active compounds have been found in *Tilia sylvestris* sapwood (113a) and *Bixa orellana* roots (163). The pharmacognosy of *Ficus glomerata* bark has also been studied (435). The constitution of munetone, a major product from *Mundulea suberosa* bark, was determined (164); and *M. sericea* bark has been shown to contain mundulone, munduserone and sericetin (191). Some of these compounds are rotenoid insecticides and crocodile repellents. Munduserone and sericetin were synthesized.

Resin acids have also received considerable attention during the past year. A symposium on diterpenic acids and related compounds was held as part of the 138th National American Chemical Society Meeting in New York, September 1960. Papers covered the chemistry of levopimaric and other resin acids, podocarpic acid, diterpene alkaloids, and synthetic studies. Of greatest interest were several papers detailing vastly improved methods for analyzing resin acid mixtures. Mass spectroscopy appears to be quite successful (103, 224), and gas chromatography also separates mixtures (306). Paper chromatography of pine and fir resin acids methylated with radioactive diazomethane has been used by the Russians (569), and the nuclear magnetic resonance of resin acids has been studied (131). Palustric acid was shown to be a major constituent of pine and spruce resin (102). The oxidation of resin acids in wood chips has been investigated (374), and the extraction of resinous substances with gasoline in a screw conveyor discussed (404). The structure of sandaracopimaric acid from sandarac gum *(Tetraclinis articulata* syn. *Callitris quadrivalis)* has been elucidated, although there was some disagreement concerning its stereochemistry (89, 167, 214). A new resin acid, 6–oxocativic acid, has been isolated from gum labdanum *(Cistus* spp.) (266). An excellent and extensive review on diterpenoids has appeared (612), and Sandermann has produced a very interesting book on natural resins, turpentines and tall oil (532). Different coniferous resins have been grouped according to their ultraviolet absorption (420). Terpenoid biogenesis has been receiving considerable attention with papers devoted to the isoprene rule (524), sesquiterpenoid biogenesis (284), and a very good paper on the biogenesis of tetracyclic triterpenes (147).

Triterpenoids are becoming increasingly significant as wood and bark extractives. The triterpenes of *Euphorbia* spp. latex (238) and *Dipterocarpus* spp. (388) have been further studied. Aphyldienol was shown to be a mixture of lanostadienol and lanosterol while obtusifoldienol was shown to be probably 24-methylenelanosterol. Four new pentacyclic triterpenoid acids have been isolated from the resin of *Commiphora glandulosa* (603). Myricolal from *Myrica gale* bark was shown to be 3β-hydroxy-Δ^{14}-taraxerenal-28 while myricadiol was the corresponding diol (525). A partial structure has been elucidated for the triterpenoid antibiotic pigment, pristimerin, from *Pristimera* spp. wood. (247). Four new triterpenols have been isolated from *Jacquinia armillaris* (391). The chemistry of ilexol, the triterpene from *Ilex* spp. barks, has been further studied (56). The elemi resins from *Canarium* spp. have been further investigated (408), and the structure of brein shown to be 3β,16β-dihydroxyursene–12 (367). Lupeol was isolated from *Crataeva religiosa* bark (124). An interesting new C–29 triterpenoid sapogenin, aegiceradienol, has been isolated from *Aegiceras majus* bark (494). This compound has an oleanene skeleton, but with the 17-methyl group eliminated. The structure of sophoradiol from *Sophora japonica* was shown to be 3β, 22β-dihydroxyoleanene–12 (313). *S. microphylla* bark (97) and *S. pachycarpa* (526) have been shown to contain matrine and other alkaloids. *Artocarpus integrifolia* wood has been found to contain a triterpene, flavonoids, glucosides, lipids and proteins (489). The triterpene, emmolic acid, and an unusual taxifolin isomer, alphitonin, were isolated from the heartwood of *Alphitonia excelsa* (80). Sitosterol, betulinic acid, ursolic acid and a C–methylated phloroglucinol derivative, syncarpic acid, were isolated from the bark of *Syncarpia laurifolia* (296a). The ether extract of *Betula verrucosa* wood was shown to consist mostly of glycerides of fatty acids plus sitosterol and sitostanol (549). No triterpenes were found. However, two new triterpenes were isolated from the leaves (192).

The ether-extractable compounds produced by saponification of *Populus* spp. barks have been investigated (466), as has the methanol extract of *P. tremuloides* inner bark (185). The ether-extractable compounds produced by saponification of various parts of *P. tremuloides* vary according to the type of tissue (464). Of particular interest was the isolation of an organosilicon compound. Spent pulping liquors from this species have also been examined and a patent issued on the isolation of p-hydroxybenzoic acid (464). The neutral part of the benzene extract of *P. tremuloides* wood has been found to contain the usual fatty substances as well as odd number fatty acids and two compounds which may be triterpenoids (270). *P. tremula* wood contained similar fatty substances and a series of sugars (371).

Two very good reviews on tree essential oils have appeared (257, 546). The essential oil of *Laurelia philippiana* bark and leaves has been analyzed and found to consist mainly of safrole, while the essential oil from *Blepharocalyx gigantea* and *B. tweediei* consists mainly of cineole (189). The volatile oil of *Leptospermum ericoides* has also been examined (141). Azulenes may be prepared from the volatile wood oil of *Guaiacum* spp. (588). The sesquiterpene, bulnesol, was isolated from *Bulnesia sarmienti* wood (157). Dysoxylonene from rosewood oil *(Dysoxylon frazeranum)* has been shown to be racemic δ-cadinene (292). The latest in a series of papers by different groups discussing the structures and stereo chemistry of the aromadendrane alcohols, globulol, ledol, and viridiflorol (himbaccol) has clarified the interrelationships in this group (246a). Palustrol is not a member of this group since the hydroxyl is at the ring junction (156a). The turpentine of *Araucaria cunninghamii* has been analyzed (214a), and the constituents of the opitcally active oily exudate from *Campnosperma auriculata* (terentang oil) have been further studied (368). *Pentaspadon officinalis* and *P. motleyi* wood oils contain appreciable amounts of 2-hydroxy-6-(heptadeca-cis-8', cis-11'-dienyl)benzoic acid (pelandjauic acid) (369).

Considerable research has been carried out during the past year on *Eucalyptus* spp. Cuminyl alcohol was isolated for the essential oil of *E. dives* (83), while the essential oil of *E. cinerea* is a good source of cineol (521). A study of the essential oils of *E. caesia* and *E. torquata* showed that both contained the new ketone, torquatone (2, 4, 6-trimethoxyl-3, 5-dimethyl benzyl isopropyl ketone) (92). An unusual ketone from *E. globulus* has now been shown to be 1-acetyl-4-isopropenylcyclopentene–1 (650). The essential oils of *E. deglupta* and *E. torelliana* have yielded a series of compounds including ocimene, carvotanacetone and nerolidol not previously found in eucalyptus oils (593). The deleterious effects of *Eucalyptus* spp. tannins (601) and ellagic and gallic acids (293) in pulping have been demonstrated. The water-soluble carbohydrates (213) and tannins (348) from *E. rostrata* have been studied, and the extractives from the heartwoods of *E. camaldulensis* (121) and other species (519) were examined. Extractives from various parts of several *Eucalyptus* spp. have been investigated and ellagic and gallic acids, juglanin, corilagin, catechin, β-glucogallin and other compounds were isolated (27, 294). The kinos produced mostly delphinidin on treatment with hydrochloric acid. Pyrogallol, catechin, gallocatechin, epicatechin, and a new flavanol, afzelchin, have been identified in *E. calophylla* kino (293a). An article on leucoanthocyanidins discusses the isolation of leucopelargonidin from the gum of *E. calophylla,* leucodelphinidin from *E. pilularis* gum and *Cleistanthus collinus* bark, and leucocyanidin from *Butea frondosa* gum (215).

An excellent paper has been written proposing a systematic nomenclature for flavonoids (206). Known compounds are listed by structure and a table of trivial names is included. Another paper deals with the stereochemical interrelationships in the flavonoid group (634). The existence of natural epidihydroflavonols is questioned. Fustin was isolated from the wood of *Rhus glabra* and *Cotinus coggygria,* and the later species also yielded 3', 4', 7-trihydroxyflavandiol-3, 4. Another report deals with flavonoids as antioxidants (405). Two flavonoids have been isolated from *Pyrus* spp. (628). *Exostemma caribaeum* bark has yielded mannitol, chlorogenic acid and three flavone glycosides, but no alkaloids (357). *Angophora lanceolata* kino has yielded tannins, farrerol and angophorol (farrerol-7-methyl ether) (79). Two more methoxyflavones, zapotin and zapotinin, have been found in *Casimiroa edulis* bark (578). *Vitex* spp. leaves have been further studied (648), and vitexin glycoside and other compounds were found in *V. lucens* wood (547) and bark (114).

The biosynthesis of isoflavones has been discussed (223, 255). A new isoflavone, sophorol, was isolated from the heartwood of *Maakia amurensis* (originally though to be *Sophora japonica)* (589). The wood of *Afromosia elata* has yielded a sterol or triterpenol together with a new 5-deoxyisoflavone, afromosin (390). The wood of *Myroxylon balsamum* and *Myrocarpus fastigiatus* has been found to contain cabreuvine 3', 4', 7-trimethoxyisoflavone) (245).

The heartwood extractives of the Moraceae have been examined (366). Dihydroflavonols appear to be characteristic of this family, the isolation of compounds such as morin being perhaps due to their derivation from naturally occurring dihydromorin. *Chlorophora tinctoria* also contained maclurin while *Morus alba* and *Maclura pomifera* also contained 2, 4, 3', 5',-tetrahydroxystilbene. Stilbenes are apparently another characteristic of this family. Saponification of extractive-free beechwood *(Fagus)* produced 4, 4'–dihydroxy–3, 3'–dimethoxystilbene in addition to the more usual compounds (600). The conversion of beechwood tannins to polyphenolic gums has also been reported (324). The inhibiting of drying of oil and polyester finishes on a number of woods has been correlated with certain extractives, especially quinoid derivatives as well as quinomethide-forming oxystilbenes (534).

The chromatographic identification of phenolic acids from several genera was studied (309). The occurrence of polyphenols and phenolic acids has been surveyed in 122 species (609). *p*-Hydroxybenzoic, gentisic, *p*-coumaric, caffeic and ferulic acids were common. Hydroquinone was found only in species of Ericaceae and *Pyrus.* Cathecol was found only in Salicaceae, while salicylic acid was found mostly in the Salicaceae. The distribution of flavonoids in leaves of Hamamelidaceae and Anacardiaceae has been surveyed (504). Myricetin appeared to be characteristic. Malvidin was found only in *Parrotia persica.* The polyphenols in several *Nothofagus* spp. are under investigation (27). Ferulic and ellagic acids and dihydrokaempferol have been isolated from *N. dombeyi* heartwood, while gallic acid, engelitin and isoengelitin were isolated from *N. procera* heartwood (319). Ellagic acid, sitosterol and its β-D-glucoside were isolated from *Aristotelia serrata* wood (116). Catalposide, the mapor glucoside of the *Catalpa* genus, has been studied and shown to be a D-glucoside and an ester of *p*-hydroxybenzoic acid (84). The variation and distribution of shikimic and quinic acids in a series of trees has been investigated (275, 475). Acid hydrolysis of the alcoholic extracts of 46 hardwoods indicates that vanillin, syringaldehyde, vanillic acid and syringic acid derivatives are native constituents (465). Some glycosides were isolated. Syringen has been isolated from *Paulownia tomentosa* bark (653).

Interest in tannins remains high. Analyses have been made on *Rhizophora conjugata* bark (64), *Rhus typhina* (297), *Polygonum coriarium*

(418), *Eucalyptus globulus* and *E. rostrata* wood and bark (262), as well as on a number of Azerbaijan (576), Philippine (39) and Russian (168) species. The composition of the tannins and polyphenols from conifer wood and bark has been studied (287), and selective spray reagents for the identification and estimation of flavonoids associated with condensed tannins developed (517). Ellagic tannins have been investigated (542). The role of catechols and hydroxyflavandiols as condensed tannin precursors has been discussed (202) as has the formation of tannins by the enzymatic oxidation of polyphenols (278). Of considerable significance for the formation of adhesives from polyphenols is a paper on the mode of reaction of catechin with formaldehyde (295). The University of California Forest Products Laboratory has been investigating the solvent seasoning of redwood (20). Tannins and related polyphenols have been shown to be responsible for various staining problems, and the chemistry of the extractives removed by solvent seasoning is being studied.

Bruguiera spp. barks have been investigated and found to be a source of tannins (64) and to contain two leucocyanidins (551). The frost resistance in *Quercus* spp. has been related to the anthocyanin content (182), while the fungicidal agent in oak heartwood is possibly tartaric acid (74). The chemistry of *Quercus* spp. tannins have been further studied (311, 403). The variation of tannin content in *Q. sessiliflora* bark was investigated (18), as was the production of tannins from Bulgarian oaks (50). Increased yields of oak tannins may be obtained by extraction with sodium sulfite and thiosulfate (18, 412). The tannins of *Terminalia chebula* have been studied in detail (279, 436), and the mineral content of *T. arjuna* bark has been investigated (71). The distribution of minerals in *Malus* spp. was also studied (400). The catechol tannins of *Salix* spp. barks have been examined (17, 586), and the sap of *S. viminalis* analyzed (469). The distribution of tannins in *Juglans regia* has been studied. The highest content was in May, and the bark and leaves were considerably richer in tannins than the wood (480). A new technique of chromatographing polyphenols and tannins on synthetic polyamides such as nylon appears quite promising (125, 208, 250, 345). Trimethylsilyl derivatives of natural tannins have been prepared (285).

Individual constituents of the hydrolyzable and condensed tannins from *Caesalpinia coriaria* (498), *Castania crenata* (449) and C. *sativa* (403) wood and bark have been studied. The commercial potentialities of *C. sativa* tannin have been discussed (421) and compared with *Schinopsis* spp. tannins (372). Most recent studies on *Acacia* spp. have involved the condensed tannins from black wattle bark *(A. mollissima)* (51, 184, 448). Robinetinidol, catechin and gallocatechin were isolated (516). Tannins were also studied from *A. arabica* (173), *A. negra* (396), Uruguayan *Acacia* spp. (507), *A. decurrens* bark and *A. dealbata* bark (528). Wattle and quebracho *(Schinopsis quebracho-colorado)* tannins have been reviewed (514), and their distribution and deposition studied (515). The heartwood of several Acacia spp. has yielded 4-hydroxypipecolic acid (136), and the alkaloid, N-methyl-β-phenylethylamine, analyzed in *A. berlandieri* (119). A lupeol-containing saponin was isolated from *A. intsia* bark (188), and *Acacia* gums have been further studied (425).

The inositols, sequoyitol, dambonitol, viburnitol and quebrachitol, have been isolated from a number of species (477). Galactitol was isolated from *Maytenus vitis-indaea* (452). The distribution of glycosides has been studied in *Nerium indicum* and *Thevetia peruviana* (144). Studies have been made on the structure of jeol gum from *Odina wodier* (156), and on the gum from *Combretum leonense* (21). Sugars have been analyzed in *Morus bombycis* bark and twigs, and the seasonal variation related to frost hardiness (527).

Evodone from *Evodia hortensis* was synthesized (584), and the structure of bhilawanol from *Semecarpus anacardium* has been determined (382). The pigments of *Maclura pomifera* root bark have been studied (426). The isolation of sesamin from *Ginkgo biloba* wood was patented (335). The absolute configuration of a number of lignans has been determined (261, 635), and the constitution of isoolivil investigated (611). Meliternatin was found to be the major compound in *Melicope mantelli* bark, and the taxonomic significance of its extractives was discussed (117). *Morinda tinctoria* heartwood has yielded morindone, damnacanthol and a new component, nordamnacanthol (429). Coumarin derivatives have been isolated from *Fraxinus ornus* (583). Marmesin, sitosterol and the alkaloid, dictamnine, have been isolated from the heartwood of *Aegle marmelos* (128). The co-factors in *Hevea brasiliensis* latex serum have been sudied (389). It was also found that analysis of the soil for phosphorus can best be carried out by analysis of the bark of this species (395). A review of the heartwood constituents of *Pterocarpus* spp. has been published (14). The chemistry and taxonomy of the Dipterocarpaceae have been reviewed, especially in relation to the leucoanthocyanins and terpenoids present (52, 453). The chemistry of heartwood formation has been discussed, and it is suggested that at the boundary a change from aerobic to anerobic conditions takes place (210). Phyllembic acid, a major constituent from *Phyllanthus emblica* (form. *Emblica officinalis*) has been studied (473).

The determination of the pH of wood and its practical importance has been discussed (535). *Tectona grandis* wood was investigated (520, 533), especially in relation to the extractives responsible for its decay resistance and the inhibition of drying of lacquers. The Vancouver Laboratory of the Forest Products Laboratories of Canada is studying the role of extractives in dimensional stabilization (34). The exothermic self heating of wood fiberboards has been correlated with the content of nonvolatile extractives (571). The Russel effect of wood appears to be due to a volatile reducing compound (433). *Feronia elephantum* bark (608) and *Carnegiea gigantea* wood (66) have been studied, and the extractives of the wood (454) and bark (476) of *Prunus mahaleb* also have been investigated.

Literature Cited

1. Aaltio, E. 1958. Ann. Acad. Sci. Fennicae, Ser. A. II (Chemical) no. 88.
2. Acerbo, S. N., W. J. Schubert, and F. F. Nord. 1960. J. Am. Chem. Soc. 82: 735.
3. Adamanis, F., W. Mizgalski, and D. Malejka. 1959. Acta Polon. Pharm. 16: 485; C. A. 54; 9206 (1960).
4. Adams, G. A. 1960. Canad. J. Chem. 38: 280.
5. Adams, J. W. 1959. U. S. Patent 2,905,558 (Sept. 22).
6. Adams, J. W. 1960. Can. Patent 591,803 (Feb. 2).
7. Adler, E. 1959. See Reference 351, page 137.
8. Adler, E., S. Delin, and K. Lundquist. 1959. Acta Chem. Scand. 13: 2149.
9. Adler, E., and R. Magnusson. 1959. Acta Chem. Scand. 13: 505.
10. Agaeva, L. N. 1958. Sbornik Trudov Azerbaidzhan. Med. Inst., No. 4: 142; C. A. 54: 17574b (1960).
11. Agnello, L. A. 1960. Ind. Eng. Chem. 52: 726.
12. Agranot, A. L. 1958. Trudy Leningrad. Lesotekn. Akad. im. S. M. Kirova no. 80: 95; 1959. *ibid.* no. 87: 91; A.B.I.P.C. 30(12): 1582 (1960.)
13. Akira, S., R. Goto, and Y. Takedo. 1959. Wood Research (Kyoto) no 21: 19, A.B.I.P.C. 30: 322.
14. Akisanya, A., C. W. L. Bevan, and J. Hirst. 1959. J. Chem. Soc.: 2679
15. Akiyoshi, S., H. Erdtman, and T Kubota. 1960. Tetrahedron 9: 237.

16. Albrecht, P., and F. Pelikan. 1960. Can. Patent 597,965 (May 17).
17. Alexa, G., and A. Chirita. 1958. Acad. rep. populare Romine, Filiala Iasi, Studii cercetari stiint., Chin., 9(1): 105; A.B.I.P.C. 30(6): 814 (1960).
18. Alexa, G., G. Chirita, and A. Chirita. 1958. Bul. inst. politeh. Iasi (N. S.) 4(8), no. 3–4: 217; G. Alexa, L. Sireteanu, G. Burghelea, and A. Chirita. Acad. rep. populare Romine, Filiala Iasi, studii cercertari stiint., Chim. 9(1): 93; A.B.I.P.C. 30: 814, 1027 (1960).
19. Anderson, A. B. 1958. Consultation Insulation Bd. Hardbd. and Particle Bd. Tech. Papers 2(4. 2); K. Steiner. *ibid.* 2(4. 11).
20. Anderson, A. B., E. L. Ellwood, E. Zavarin, and R. W. Erickson. 1960. Forest Prods. J. 10: 212; A. B. Anderson and W. B. Fearing. *ibid.* to be published.
21. Anderson, D. M. W., E. L. Hirst, and N. J. King. 1959. Talanta 3: 118; C. A. 54: 9008e (1960).
22. Anderson, J. K., F. W. Herrick, and K. R. Gray. 1959. Can. Patent 582,497 (9/1); see U. S. Patent 2,845,450.
23. Anderson, R. L., and F. H. Kaufert. 1959. Forest Sci. 5(4): 356.
24. Annergren, G. E., and Rydholm. 1959. Svensk Papperstidn 62(20): 737–746.
25. Anon. 1959. Can. Pulp Paper Ind. 12(10): 18, 23.
26. Anon. 1959. Chem. Week 84(18): 33, 37.
27. Anon. 1959. C.S.I.R.O., Division of Forest Products, Melbourne.
28. Anon. 1960. Bulletin Nos. 18 and 19, Tall Oil Products Division, Pulp Chemicals Assoc., N. Y.
29. Anon. 1960. Chem. Eng. 67(6): 86, 88.
30. Anon. 1960. Chem. Eng. News 38 (11): 47.
31. Anon. 1960. Chem. Eng. News 38 (21): 24.
32. Anon. 1960. Chem. Eng. News 38 (26): 40, 42.
33. Anon. 1960. Chem. Week 86 (1): 34–35.
34. Anon. 1960. Forest Prods. J. 10(1): 7A.
35. Anon. 1960. Forest Prods. J. 10: 428.
36. Anon. 1960. Paper Trade J. 144(40): 39.
37. Anon. 1960. Paper Trade J. 144(37): 39.
38. Anon. 1960. Pap. ja Puu 42: 31.
39. Anon. 1960. Tech. Note No. 7, Forest Prods. Res. Inst., College Laguna, Philippines.
40. Antonaccio, L. D. 1960. J. Org. Chem. 25: 1262.
41. Antonaccio, L. D., and O. R. Gottlieb. 1959. Anais assoc. brasil. quim. 18: 183; C. A. 54: 11163 (1960).
42. Arthur, H. R., W. H. Hui, and Y. L. Ng. 1959. J. Chem. Soc.: 1840, 4007; H. R. Arthur and Y. L. Ng. *Ibid.*: 4010.
43. Arya, V. P., and D. W. Mathieson. 1959. J. Chem. Soc.: 3623.
44. Aspinall, G. O., and A. Nicolson. 1960. J. Chem. Soc.: 2503.
45. Aspitarte, T. R. 1959. PhD. thesis Oregon State College, Diss. Abstr. 19(12): 3084.
46. Assarsson, A., B. Lindberg, and H. Vorbruggen. 1959. Acta Chem. Scand. 13(7): 1395.
47. Babin, D. R., J. A. Findlay, T. P. Forrest, F. Fried, M. Goetz, Z. Valenta, and K. Wiesner. 1960. Tetra. Letters No. 15: 31.
48. Bartlett, M. F., W. I. Taylor, and Raymond-Hamet. 1959. Compt. Rend. 249: 1259; C. A. 54: 16473e (1960).
49. Bartunek, R. 1959. Tappi 42: 553.
50. Basan, Ya., and R. Bichev. 1956. Godishnik Khim.-Tekhnol. Inst. 3 (2): 111; C. A. 54: 16887e (1960).
51. Basinski, A., and M. Czerniawski. 1959. Roczniki Chem. 33: 1141, 1407; M. Czerniawski and T. Wysocki. *ibid.*: 1415; C. A. 54: 12627cd (1960).
52. Bate-Smith, E. C., and T. C. Whitmore. 1959. Nature 184(4689): 795.
53. Battersby, A. R., and H. F. Hodson. 1960. J. Chem. Soc.: 736; A. R. Battersby, R. Binks, H. F. Hodson, and D. A. Yeowell. *ibid.*: 1848.
54. Bauer, S. T. 1959. Amer. Paint. J. 44(5): 26.
55. Baumgartner, R., and K. Leupin. 1959. Pharm. Acta. Helv. 34: 296.
56. Baurna, A. K., and P. K. Bose. 1959. Bull. Agr. Chem. Soc. Japan. 23: 217; C. A. 54; 1594f (1960).
57. Bausch, H., and Hartler. 1960. Svensk Papperstidn 63(9): 279–285.
58. Bečka, J., Z. Šťota, M. Toman, and V. Staník. 1957. Sbornik Výzkumných Prací z Oboru Celulosy a Papíru 2: 201.
59. Beckum, W. G. van, and R. W. Miller. 1960. U. S. Patent 2,926,115 (2/23).
60. Beketovskii, S. N. 1957. Nauch. Trudy Ukrain. Sel'sk.-Khoz. Akad. 9: 441; 1959. Referat. Zhur., Khim. (11): 431.
61. Bender, F. 1960. Canada Lumberman (Feb.).
62. Benedict, S. W., and T. M. Kelly 1960. U. S. Patent 2,927,033 (March 1).
63. Benedict, S. W., T. M. Kelly, and P. B. Jacox. 1959. Can. Patent 588,-622 (Dec. 8).
64. Bennett, H., and R. D. Coveney. 1959. Trop. Sci. 1:116; C. A. 54; 2795a (1960).
65. Bernauer, K., in L. Zechmeister, "Progress in the Chemistry of Organic Natural Products", Vol. 17, Springer-Verlag, Vienna, 1959.
66. Berry, J. W., A. Ho, and C. Steelink. 1960. J. Org. Chem. 25: 1267.
67. Bertho, A., M. Koll, and M. I. Ferosie. 1958. Chem. Ber. 91: 2581.
68. Bevan, C. W. L. 1958. West African J. Biol. Chem. 2(2): 36.
69. Beyerman, H. C., and R. W. Rooda. 1959. Koninkl. Ned. Akad. Wetenschap. Proc. Ser. B 62: 187; 1960. *ibid.* 63: 154; C. A. 54: 2393d, 18573c.
70. Bhakuni, D. S., and N. M. Khanna. 1959. J. Sci. and Indus. Res. 18B: 494; C. A. 54: 17438i (1960).
71. Bhale, H. S., and A. P. Saxena. 1957. J. Vikram Univ. 1 (3): 111; C. A. 54: 9008d (1960).
72. Bhavanandan, V. P., and G. P. Wannigama. 1960. J. Chem. Soc.: 2368.
73. Bible, R. H. 1960. Tetra. Letters No. 9: 20; Tetrahedron 11: 22.
74. Bilbrick, J. D. 1959. Plant Disease Reptr. 43: 936.
75. Billek, G. 1959. See Reference 351, page 207.
76. Binko, I., and J. Kolar. Brit. Patent 818, 034 (8/12); C. A. 54: 11531c (1960).
77. Binko, I., J. Kolar, and K. Müller. 1959. Veda a vyzkum v prumyslu kozedelnem 5: 22; A. Travnik and I. Binko. Drevo (Czech) 14(2): 57; C. A. 54: 937d (1960).
78. Birch, A. J., H. F. Hodson, B. Moore, H. Potts, and G. F. Smith. 1960. Tetra. Letters no. 19: 36.
79. Birch, A. J., D. G. Pettit, A. J. Ryan, and R. N. Speake. 1960. J. Chem. Soc.: 2063.
80. Birch, A. J., E. Ritchie, and R. N. Speake. 1960. J. Chem. Soc.: 3593.
81. Bland, D. E. 1960. Biochem. J. 75: 195.
82. Blaricom, L. E. van, and K. R. Gray. 1959. Can. Patents 577,006 (6/2), 577,691 (6/16).
83. Blumann, A., and G. J. H. Melrose. 1959. Perf. Ess. Oil Rec. 50: 769.
84. Bobbitt, J. M., H. Schmid, and T. B. Africa. 1960. 138th Natl. ACS meeting, New York, 9/12, p. 30P of abstracts.
85. Boggs, L. A., and A. J. Wiley. 1959. Can. Patent 581,310 (Aug. 11).
86. Boldt, C. E., and C. Arbogast. 1960. "Charcoal kiln operation for improved timber stands," Forest Products Jour. 10(1): 42–44.
87. Borísek, R. 1957. Sbornik Výzkumných Prací z Oboru Celulosy a Papíru 2: 184.
88. Borísek, R. 1960. Czech. Patent 84,217; 1960. Referat. Zhur., Khim. (8): 565.
89. Bose, A. K. 1960. Chem. and Ind.: 1104.
90. Bouveng, H. O. 1959. Acta Chem. Scand. 13(9): 1869, 1877.
91. Bouveng, H. O., and H. Meier. 1959. Acta Chem. Scand. 13(9): 1884.
92. Bowyer, R. C., and P. R. Jefferies. 1959. Austral. J. Chem. 12: 442.
93. Brasch, D. J., J. K. N. Jones, T. J. Painter, and P. E. Reid. 1959. Pulp Paper Mag. Canada 60: T342; D. J. Brasch and J. K. N. Jones. Canad. J. Chem. 37(9): 1538.
94. Bredenberg, J. B. 1960. Acta Chem. Scand. 14: 385,556.
95. Briggs, L. H., and R. C. Cambie. 1960. Tetrahedron 8: 356.
96. Briggs, L. H., R. C. Cambie, and J. L. Hoare. 1959. Tetrahedron 7: 262.
97. Briggs, L. H., R. C. Cambie, R. H. Holdgate, and R. N. Seelye. 1960. J. Chem. Soc.: 1955.
98. Briggs, L. H., R. C. Cambie, R. N. Seelye, and A. D. Warth. 1959. Tetrahedron 7: 270.
99. Brooker, E. G. 1959. New Zealand J. Sci. 2(2): 212.
100. Brouillard, R. E., and L. Katz. 1960. Can. Patent 599,015 (May 31).
101. Brukner, J. S. 1959. Can. Patent 583,-846 (Sept. 22).
102. Bruun, H. H., S. Gasland, and G. Lundquist. 1959. Acta Chem. Scand. 13: 1039.
103. Bruun, H. H., R. Ryhage, and E. Stenhagen. 1958. Acta Chem. Scand. 12: 1355.
104. Bryant, L. H., and F. R. Humphreys. 1958. Composite Wood (India) 5 (2/3): 41.
105. Buchanan, M. A., and E. E. Dickey. 1960. J. Org. Chem. 25: 1389.
106. Bu'Lock, J. D., and H. G. Smith. 1960. J. Chem. Soc.: 502.
107. Burke, J. T., Jr. 1959. U. S. Patent 2,901,439 (Aug. 25).
108. Burrows, C. H. 1960. Pacific Northwest Meeting Forest Prods. Res. Soc., Eugene, Ore., 5/10.
109. Busche, L. R. 1960. Ph.D. Thesis. The Institute of Paper Chemistry, Appleton, Wis.
110. Bushong, R. M., C. W. Clark, and F. P. Holloway. 1960. Can. Patent 590,641 (Jan. 12).
111. Buzas, A., M. Osowiecki, and G. Regnier. 1959. Compt. Rend. 248: 2791.
112. Byrd, G. J. 1960. U. S. Patent 2,933,-452 (April 19).
113. Byrd, G. J. 1959. Can. Patent 589,887 (Dec. 29).

113a. Cahen, R., and C. Hirsch. 1960. Compt. Rend. 251(1): 161.
114. Cambie, R. C. 1959. New Zeal. J. Sci. 2(2): 230.
115. Cambie, R. C. 1959. New Zealand J. Sci. 2(2): 254.
116. Cambie, R. C. 1959. New Zeal. J. Sci. 2(2): 257.
117. Cambie, R. C. 1960. J. Chem. Soc.: 2376.
118. Cambie, R. C., and B. F. Cain. 1960. New Zeal. J. Sci. 3(1): 121.
119. Camp, B. J., and J. A. Moore. 1960. J. Am. Pharm. Assoc., Sci. Ed. 49(3): 158.
120. Canham, D. H. 1960. Univ. Microfilms, L. C. Card No. Mic 60–984; Dissertation Abstr. 20: 3964.
121. Capito, L., and L. Panizzi. 1959. Ann. chim. (Rome) 49: 771; C. A. 53: 19385e.
122. Chakraborty, D. P., M. Purkayastha, and P. K. Bose. 1959. Proc. Natl. Inst. Sci., New Delhi 25B(1): 8.
123. Chakravarti, D., et al. 1960. Tetra. Letters No. 10: 10; No. 11: 25; No. 12: 33.
124. Chakravarti, R. N., D. Chakravarti, and R. Banerjee. 1959. Bull. Calcutta School Trop. Med. 7: 105; C. A. 54: 11384c (1960).
124a. Chalov, N. V. 1959. U.S.S.R. patent 119, 491 (4/15).
125. Chandler, B. V., and T. Swain. 1959. Nature 183(4666): 989.
126. Chatterjee, A., S. Bose, and C. Ghosh. 1959. Tetrahedron 7: 257.
127. Chatterjee, A., S. Ghosol, and G. Majumdar. 1960. Chem. and Ind.: 265; S. Ghosol, and G. Majumdar. *ibid.*: 19.
128. Chatterjee, A., and S. K. Roy. 1959. J. Indian Chem. Soc. 36: 267; C. A. 53: 22922h.
129. Chidester, G. H. 1960. Tappi 43(9): 216A.
130. Chidester, G. H. J. F. Laundrie, and E. L. Keller. 1960. Tappi 43(10): 876.
131. Chien, J. C. W. 1960. J. Am. Chem. Soc. 82: 4762.
132. Chopra, I. C., K. L. Handa, and A. B. Kar. 1960. J. sci. industr. Res. India 18C(7): 133.
133. Chow, Y.-L., and H. Erdtman. 1960. Proc. Chem. Soc. London: 174.
134. Christensen, G. N., and K. E. Kelsey. 1959. Australian J. Appl. Sci. 10: 284.
135. Cisney, M. E., and D. W. Goheen. 1959. U. S. Patent 2,908,716 (Oct. 13).
136. Clark-Lewis, J. W., and P. I. Mortimer. 1959. Nature 184(4694): 1234.
137. Collins, E. H., and E. M. Williston. 1960. Canad. Patent 590,373 (1/5).
138. Conroy, H., et al. 1960. Tetra. Letters No. 6: 1.
139. Cooke, N. J., and R. P. Hansen. 1959. Chem. and Ind.: 1516; R. P. Hansen and N. J. Cooke. New Zealand J. Sci. 2(3): 336.
140. Cooper, R. H. 1959. U. S. Patent 2,913,787 (Nov. 24).
141. Corbett, R. E., and M. G. C. Gibson. 1959. J. Sci. Food Agric. 10(3): 198.
142. Cordingly, R. H. 1959. Thesis. Institute Paper Chemistry, Appleton, Wis. 80 p.
143. Corey, E. J., and W. R. Hertler. 1959. J. Am. Chem. Soc. 81: 5209.
144. Cosme, L. L., J. Maranon, and V. P. Arida. 1958 Phil. J. Sci. 87(1): 1.
145. Costa, A. F., and J. C. Vale. 1958. Boletim da Escola de Farmacia, Universidade de Coimbra No. 13/14, 1953/1954: 57; C. A. 53: 5419 (1959).
146. Cox, B. D., H. M. Owen, and R. R. Fuller. 1960. Tappi 43(10): 163A–167A.
147. Crabbe, P. 1959. Record Chem. Progr. 20(4): 189.
148. Creanga, E., C. Chelaru, V. Lupascu, E. Nichiforescu, and D. Serban. 1959. Farmacia 7: 413; C. A. 54: 11376c (1960).
149. Crittendon, B. C. 1960. U. S. Patent 2,930,755 (3/29).
150. Cucu, V., and E. Tarpo. 1959. Pharmazie 14: 316; C. A. 54: 7977e (1960).
151. Dashkevich, B. N., and M. N. Karpinskiĭ. 1959. Zhur. Priklad. Khim. 32: 2339.
152. Dassler, H. G. 1960. Holz Roh-u.-Werkstoff 18: 162.
153. Dayan, E. E., and W. R. Smith. 1959. Forest Prod. Jour. 9(11): 395.
154. Dence, C., and K. Sarkanen. 1960. Tappi 43: 87.
155. Desalbres, L. 1959. Bull. soc. chim. France: 1348; L. Desalbres, L. M. Dupaya, and R. Dubearnes. Rev. franc. corps gas 6: 681; C. A. 54: 7147d, 10316h (1960).
156. Dhar, P. K., and S. Mukherjee. 1959. J. sci. industr. Res. India 18B(5): 219.
156a. Dolejs, L., V. Herout, and F. Sorm. 1960. Chem. and Ind.: 267.
157. Dolejs, L., A. Mironov, and F. Sorm. 1960. Tetra. Letters No. 11:18.
158. Dostal, E. J., L. M. Marraccini, and T. N. Kleinert. 1960. Holzforschung 14: 21–25.
159. Dostal, E. J., L. M. Marraccini, and T. N. Kleinert. 1960. Pulp Paper Mag. Can. Conv. Issue: 1–8.
160. Doughty, J. B. 1959. Can. Patent 586,876 (Nov. 10).
161. Doughty, J. B. 1959. U. S. Patent 2,911,383 (Nov. 3).
162. Doughty, J. B., and W. R. Cook. 1959. Can. Patent 589,807 (Dec. 29).
163. Dunham, N. W., and K. R. Allard. 1960. J. Amer. Pharm. Ass. (Sci. Ed.) 48(4): 218.
164. Dutta, N. L. 1959. J. Indian Chem. Soc. 36: 165.
165. Dutta, P. C., and P. K. Ramachandran. 1960. Proc. Chem. Soc. London: 997.
166. Edmonson, C. H. 1958. Corrosion, Houston. 13: 33; For. Abs. 21(2): 314 (1960).
167. Edwards, O. E., A. Nicolson, and M. N. Rodger. 1960. Canad. J. Chem. 38: 663.
168. Egorov, B. A. 1958. Vsesoiuznoe Soveshchanie po Rastitel'nym Resursam SSSR, Leningrad, 1954. Sostoianie i perspektivy izuchemia rastitel'nykh resursov SSSR. p. 385. Moskva, Akademiia Nauk SSSR.
169. Eidus, B. R. 1955. "Processing wood tar based on simultaneous pyrolysis of tar and wood," Hrudy so lesnomu Kloz. Zapad. Sibir. Filiala, Akad. Nauk. S.S.S.R., Otdel. Vsesoyz. hauch. Inzhener—Tekh. Obshchestva Metalliuzor, No. 2,276–82.
170. Ekman, K. H., and J. J. Lindberg. 1960. Paperi ja Puu 42: 21.
171. Elderfield, R. C. 1960. Amer. Scientist 48(2): 193.
172. Ellefsen. Ø 1960. Norsk. Skog. 14(3): 105–112.
173. Endres, H., H. El Sissi, and M. Hilal. 1959. Egypt. J. Chem. 2(2): 375.
174. Endres, H., P. Stadler, and F. von der Crone. 1960. Leder 11: 1; H. Endres and P. Stadler. 1959. Angew. Chem. 71(22): 704; Leather Mfr.: 80; C.A. 54: 14739f.
175. Engel, B. G. 1959. Helv. Chim. Acta 42: 1127.
176. Enkvist, T. 1960. Svensk Kem. Tidskr. 72: 93.
177. Enkvist, T., and K. Turunen. 1960. Paperi ja Puu 42(4a): 157.
178. Enzell, C. 1960. Acta Chem. Scand. 14: 81.
179. Erdtman, H. 1959. So. African Indus. Chem. 13(5): 104.
180. Erdtman, H., and T. Norin. 1960. Chem. and Ind.: 622; 1959. Acta Chem. Scand. 13(6): 1124.
181. Ermolenko, M. F., I. P. Kutanov, and L. I. Malishevskaya. 1958. Trudy Inst. Lesokhoz. Problem Akad. Nauk Latv. S.S.R. 16: 101.
182. Es'kin, B. I. 1960. Doklady Akad. Nauk SSSR 130: 1158 .
183. Esterer, A. K. 1959. Pulp Paper Mag. Can. 60(6): 162, 164, 166, 168.
184. Evelyn, S. R. 1959. J. Soc. Leather Trades' Chem. 43: 301; C.A. 54: 940a (1960).
185. Faber, H. B. 1960. Tappi 43: 406.
186. Fahey, D. J., R. M. Kingsbury, E L. Keller, and J. S. Martin. 1960. Forest Prod. Lab. Report 2187, 21 p.
187. Fairbairn, J. W. 1959. Planta Med. 7: 406.
188. Farooq, O., I. P. Varshney, and Z. Naim. 1959. Ann. pharm. franc. 17: 442.
189. Fester, G. A., E. A. Martinuzzi, J. A. Retamar, and A. I. A. Ricciardi. 1958. Bol. acad. nacl. cienc. (Cordoba, Rep. Arg.) 40: 189.
190. Fetizon, M., and J. Delobelle. 1960. Tetra Letters No. 9: 16.
191. Finch, N., and W. D. Ollis. 1960. Proc. Chem. Soc. London: 176; J. R. Herbert, W. D. Ollis, and R. C. Russell. *ibid.*: 177; B. F. Burrows, and W. D. Ollis. *ibid.*: 177.
192. Fischer, F. G., and N. Seiler. 1959. Justus Liebigs Annalen 626 (1/3): 185.
193. Flaig, W. 1959. See Reference 351, page 227.
194. Flaig, W., U. Schobinger, and H. Deuel. 1959. Chem. Ber. 92: 1973.
195. Flenner, A. L. 1960. Can. Patent 595, 214 (March 29).
196. Foss, E. W. 1960. Noeast. Logger 8(8): 12.
197. Franck, B. 1960. Naturwissenschaften 47(8): 169.
198. Freeman, H. 1960. Can. Patent 595, 182 (March 29).
199. Freĭdin, A. S., Y. M. Malinskiĭ, and V. L. Karpov. 1959. Vysokomol. Soedin. 1: 784; 1960. Referat. Zhur., Khim. (4): 613.
200. Freudenberg, K. 1959. Chem. Ber. 92: LXXXIX.
201. Freudenberg, K. 1959. See Reference 351, page 121.
202. Freudenberg, K. 1960. Experientia 16 (3): 101; A.B.I.P.C. 30(11): 1415.
203 Freudenberg, K., and B. Lehmann. 1960. Chem. Ber. 93: 1354.
204. Freudenberg, K., and G. S. Sidhu. 1960. Tetra. Letters no. 20:3.
205. Freudenberg, K., and K. Weinges. 1959. Tetra. Letters No. 17: 19.
206. Freudenberg, K., and K. Weinges. 1960. Tetrahedron 8: 336.
207. Freudenberg, K., H. Wilk, H. U. Leuck, L. Knof, and T. H. Fung. 1960. Ann. Chem. 630: 1.
208. Freukel', P. I., and A. N. Mikhailov. 1959. Zhur. Prikl. Khim. 32(10): 2283.
209. Frey, H. P. 1959. Holz Roh- u. Werkstoff 17: 313.
210. Frey–Wyssling, A., and H. H. Bosshard. 1959. Holzforschung 13: 129; C. A. 54: 7834h (1960).

211. Fridman, G. A., and N. S. Maizel. 1956. "The preparation of oils from wood tars and their use as plasticizers," V Pomosheh hesokhim iku (Moscow) Sbornik. 85–96.
212. Fukuzumi, T. 1959. J. Japan Wood Research Soc. 5: 222.
213. Fumasoni, S. 1959. Cellulosa e Carta 10(9): 21; For. Abs. 21 (2): 299 (1960).
213a. Galbraith, M. N., E. Ritchie, and W. C. Taylor. 1960. Austral. J. Chem. 13: 427.
214. Galik, V., J. Kuthan, and F. Petru. 1960. Chem. and Ind.: 722; 1959. Tetrahedron 7: 223; Naturwiss. 46: 322.
214a. Gallagher, M. J., and M. D. Sutherland. 1960. Austral. J. Chem.. 13: 367.
215. Ganguly, A. K., and T. R. Seshadri. 1958. J. sci. industr. Res. India 17B (4): 168.
215a. Garber, J. D., and R. E. Jones. 1960. U. S. patent 2,929,823 (3/22).
216. Gardner, J. A. F., and G. M. Barton. 1960. Forest Prods. J. 10: 171.
217. Gardon, J. L., and B. Leopold. 1959. Can. Patent 587,337 (Nov. 17).
218. Gardon, J. L., and B. Leopold. 1959. Can. Patent 587,237 (Nov. 17).
219. Gardon, J. L., and B. Leopold. 1960. U. S. Patent 2,934,531 (April 26).
220. Gardon, J. L., and S. G. Mason. 1958. Ind. Eng. Chem., Chem. Eng. Data Ser. 3(1): 115.
221. Garnett, J. L., and J. W. T. Merewether. 1959. Chem. and Ind. (London) (39): 1215.
222. Gaslini, F., and L. Z. Nahum. 1959. Svensk Papperstidn. 62: 520.
223. Geissman, T. A., J. W. Mason, and J. R. Rowe. 1959. Chem. and Ind.: 1577; T. A. Geissman, and J. W. Mason. 1960. *ibid.*: 291.
224. Genge, C. A. 1959. Anal. Chem. 31: 1750.
225. Gessel, S. P. 1960. Compost Sci. 1(1): 26.
226. Ghatak, V. R., D. K. Datta, and S. C. Ray. 1960. J. Am. Chem. Soc. 82: 1728.
227. Gierer, J., B. Alfredsson, and S. Söderberg. 1960. Svensk Papperstidn. 63: 201.
228. Giertz, H. W. 1959. Svensk Papperstidn 62 (17): 612–618.
229. Giesen, J. 1959. Can. Patent 581,528 (Aug. 18).
230. Gilman, R. E. 1959. Univ. Microfilms, L. C. Card No. Mic 59–4911; Diss. Abstr. 20: 1578.
231. Giral, F., and L. R. Hahn. 1960. J. Chem. Soc.: 2373.
232. Goheen, D. W. 1959. Can. Patent 585,622 (Oct. 20).
233. Goheen, D. W., and W. M. Hearon. 1959. U. S. Patent 2,914,567 (Nov. 24).
234. Goheen, D. W., W. M. Hearon, M. E. Cisney, and J. D. Wethern. 1959. U. S. Patent 2,914,568 (Nov. 24).
235. Goheen, D. W., W. M. Hearson, M. E. Cisney, and J. D. Wethern. 1960. Can. Patent 595,832 (April 5).
236. Goldschmid, O., and L. F. Maranville. 1959. Anal. Chem. 31: 370.
237. Goncalves de Lima, O., I. L. d'Albuquerque, M. P. Machado, G. P. Pinto and M. G. Maciel. 1956. Anais. soc. biol. Pernambuco 14: 136.
238. Gonzalez, A. G., and J. L. B. Funes. 1959. Anales real soc. espan. fis. y quim. 55B: 93; A. G. Gonzalez, and R. Barrera. 1957. *ibid.* 53B: 709; C. A. 53: 20123h (1959).
239. Goodman, N. S., and S. M. Siegel. 1959. Nature 184(4679): 53.
240. Goodwin, S., A. F. Smith, and E. C., Horning. 1960. Chem. and Ind.: 691.
241. Goodwin, S., A. F. Smith, A. A. Velasquez, and E. C. Horning. 1959. J. Am. Chem. Soc. 81: 6209.
242. Gopinath, K. W., T. R. Govindachari, and V. R. Rao. 1960. Tetrahedron 8: 293; K. W. Gopinath. T. R. Govindachari, P. C. Parthasarathy, and N. Viswanathan. 1959. J. Chem. Soc.: 4012.
243. Gorecki, E. W., and J. M. Pepper. 1959. Can. J. Chem. 37: 2089.
244. Gorman, M., N. Neuss, N. J. Cone. and J. A. Deyrup. 1960. J. Am. Chem. Soc. 82: 1142.
245. Gottlieb, O. R., and M. T. Magalhaes. 1959. Anais Assoc. brasil. quim. 18: 89; Acad. Bras. de Cien. An. 31 (3): 411; C.A. 54: 9911d (1960).
246. Gottlieb, O. R., and M. T. Magalhaes. 1960. Perfumery Essent. Oil Record 51: 18, 69; 1959. J. Org. Chem. 24: 2070.
246a. Graham, B. A., P. R. Jefferies, G. J. H. Melrose, K. J. L. Thieberg, and D. E. White. 1960. Austral. J. Chem. 13: 372.
247. Grant, P. K., A. W. Johnson, P. F. Juby, and T. J. King. 1960. J. Chem. Soc.: 549.
248. Grantham, J. B. 1959. Northwest. Wood Prod. Clinic Proc., 14th, p. 18.
249. Grassmann, W., and H. Endres. 1959. Leather Mfr.: 31; Leder 10: 237; Angew. Chem. 71(22): 703.
250. Grassmann, W., H. Endres, M. Oppelt, and H. E. Sissi. 1959. Leder 10: 149.
251. Gray, K. R., and H. L. Crosby. 1959. Can. Patent 581,482 (Aug. 18).
252. Gray, K. R., J. C. Steinberg, and H. L. Crosby. 1959. Can. Patent 582,532 (9/1).
253. Greiner, W. T. 1960. Paper Trade J. 144(5): 27.
254. Griffith, T. R., and J. E. Tyson. 1959. Can. Patent 589,657 (Dec. 29).
255. Grisebach, H. 1959. Z. Naturforsch. 14b: 802; C.A. 54: 15535d (1960).
256. Grundon, M. F., and J. E. B. McGarvey. 1960. J. Chem Soc.: 2739.
257. Guenther, E., K. Kulka, and J. A. Rogers. 1959. Anal. Chem. 31: 679.
258. Gupta, P. R., and D. A. Goring. 1960. Can. J. Chem. 38: 248.
259. Gupta, P. R., and D. A. Goring. 1960. Can. J. Chem. 38: 270.
260. Gupta, P. R., R. F. Robertson, and D. A. Goring. 1960. Can. J. Chem. 38: 259.
261. Gurevich, A. I., M. N. Kolosov, and M. M. Shemyakin. 1960. Doklady Akad. Nauk SSSR 131: 833; C.A. 54: 16442f.
262. Gutierrez G. de la, and M. G. Mugica. 1958. An. Inst. For. Invest. Exp. Madrid 30(3): 155; For. Abs. 21(2): 323 (1960).
263. Haas, J. 1960. U. S. Patent, 2,926,391 (3/1); M. J. Reider. 1960. U. S. Patent 2,925,626 (2/23).
264. Hall, R. B., J. H. Leonard, and G. A. Nicholls. 1960. Forest Prods. J. 10: 263.
265. Halliday, J. E. 1959. J. Amer. Pharm. Assoc. (Sci. Ed.) 48(12): 722.
266. Halsall, T. G., and M. Moyle. 1960. J. Chem. Soc.: 1324.
267. Hamilton, J. K., and N. S. Thompson. 1960. Pulp Paper Mfg. Can. 61(4): T263–272.
268. Harkin, J. M. 1959. Ph. D. Thesis. University of Heidelberg.
269. Harkin, J. M., and C. J. Coscia. 1960. Experientia 16: 80.
270. Harrocks, J. 1960. Ph.D. Thesis Inst. Paper Chem.; A.B.I.P.C. 30: 1213.
271. Hartler, N. 1959. Svensk Papperstidn 62(13): 467–470.
272. Hartler, N., and O. Sundberg. 1960. Svensk Papperstidn 63(8): 263–271.
273. Hartmann, W. 1959. U. S. Patent 2,907,645 (Oct. 6).
274. Hasegawa, M., and T. Miyoshi. 1960. J. Japan. For. Soc. 42: 222.
275. Hasegawa, M., and T. Tateoka. 1960. J. Japan. For. Soc. 42: 224.
276. Hata, K., and M. Sogo. 1959. Kagawa Daigaku Nogakubu Gakuzyutu Hokoku 11: 270; C. A. 54: 10316c (1960).
277. Hata, K., and M. Sogo. 1960. J. Japan Wood Res. Soc. 6: 71 .
278. Hathway, D. E. 1959. Leather Mfr.: 30.
279. Hathway, D. E. 1959. Trop. Sci. 1(2): 85.
280. Haxo, H. E., Jr., and G. S. Mills. 1960. Can. Patent 591,081 (Jan. 19).
281. Haxo, H. E., Jr., and G. S. Mills. 1960. Can. Patent 591,697 (Feb. 2).
282. Hegnauer, R., and L. Fikenscher, 1959. Pharm. Ztg. 104(38): 991.
283. Hein, K. L., and D. L. Lindsey. 1960. U. S. Patent 2,923,681 (Feb. 2).
284. Hendrickson, J. B. 1959. Tetrahedron 7: 82.
285. Henglein, F. A., and J. Krämer. 1959. Chem. Ber. 92: 2585.
286. Hergert, H. L. 1960. J. Org. Chem. 25: 405.
287. Hergert, H. L. 1960. Forest Prods J. 10: 610.
288. Heritage, C. C. 1959. Can. Patent 583,691 (9/22); see U. S. Patent 2,736,063.
289. Heritage, C. C., and L. E. Dowd. 1959. Can. Patent 581,604 (8/18); see U. S. Patent 2,890,231 (6/9/59).
290. Herrick, F. W., and R. J. Conca. 1960. Forest Prods. J. 10: 361; 14th Annual Meeting FPRS, Montreal (6/7); F. W. Herrick and L. H. Bock. 1959. Canadian Patents 577,506 (6/9), 577,536 (6/9), 577,512 (6/9), 582,523 (9/1), 577,692 (6/16); J. C. Steinberg and K. R. Gray. 1959. Can. Patent 582,498 (9/1); see U. S. Patent 2,823,223.
291. Higuchi, T. 1959. See Reference 351, page 161.
292. Hildebrand, R. P., and M. D. Sutherland. 1959. Austral. J. Chem. 12: 678.
293. Hillis W. E., and A. Carle. 1959. Appita, 13(2): 74; C.A. 54: 888d (1960).
293a. Hillis, W. E., and A. Carle. 1960. Austral. J. Chem. 13: 390.
294. Hillis, W. E., and A. Clarke. 1960. Biochem. J. 74: 607; W. E. Hillis. Nature 186: 635.
295. Hillis, W. E., and G. Urbach. 1959. J. App. Chem. 9: 474.
296. Hirose, Y., and T. Nakatsuka. 1959. Bull. Agr. Chem. Soc. Japan 23: 140, 143; C.A. 54: 159th (1960).
296a. Hodgson, D., E. Ritchie, and W. C. Taylor. 1960. Austral. J. Chem. 13: 385.
297. Hofman, J., and B. Heger. 1958. Prace Vyzkumn. Vst. Lesu. CSR 15: 49.
298. Hofman, W., T. Ostrowski, T. Urbanski, and M. Witanowski. 1960. Chem. and Ind. (London) (4): 95.
299. Holderby, J. M., and W. A. Moggio. 1960. J. Water Pollution Control Federation 32: 171.
300. Holker, J. S. E., M. Cais, F. A. Hochstein, and C. Djerassi. 1959. J. Org. Chem. 24: 314.
301. Holmberg, B. 1957. Arkiv Kemi 12: 41.

302. Holmberg, B. 1959. Arkiv Kemi 13: 199.
303. Holmberg, B. 1958. Arkiv Kemi 13: 211.
304. Horii, Z., T. Katagi, and Y. Tamura. 1960. Chem. and Ind.: 1088; Z. Horii, and T. Tanaka. 1959. *ibid.*: 1576.
305. Hove, L. van. 1959. Tetrahedron 7: 104.
306. Hudy, J. A. 1959. Anal. Chem. 31: 1754.
307. Humphreys, F. R. 1959. New S. Wales Forestry Commission, private report.
308. Hyttinen, A., J. S. Martin, and E. L. Keller. 1960. Forest Prod. Lab. Report 2180, 21 p.
309. Ibrahim, R. K., and G. H. N. Towers. 1960. Arch. Biochem. Biophys. 87: 125.
310 Ingulevskii, G. V., and V. G. Kostenko. 1959. Vestn, Leningrad Inst., no. 4: 154; A.B.I.P.C. 30(12): 1548 (1960).
311. Ionesco–Matiu, A. 1959. Ind. chim. belge 24: 1495; C.A. 54: 7194e (1960).
312. Ishikawa, H. 1958. Mem. Ehime Univ. (Sect. VI) 4(1): 1; 1959. Biol. Abstr. 33: 3928.
313. Ishimasa, S. 1960. Yakugaku Zasshi 80: 304; C.A. 54: 18584c.
314. Istas, J. R., and E. L. Raekelboom. 1959. Bull. agr. Congo Belge. 50: 697; C.A. 54: 1807c (1960).
315. Ito, K., and I. Uchida. 1959. J. Pharm. Soc. Japan. 79: 1108; K. Ito. 1960. Yakugaku Zasshi 80: 705; C.A. 54: 18887e.
316. Ivancic, A., and S. A. Rydholm. 1959. Svensk Papperstidn. 62: 554.
317. Jacopian, V., and P. Schorning. 1959. Zellstoff u. Papier 8 (9): 332–340.
318. Jaminet, L. V. 1959. Seifen-Ole-Fette-Wachse 85(22): 665.
319. Janes, N. F., and J. W. W. Morgan. 1960. J. Chem. Soc.: 2560.
320. Janot, M. M., A. Cave, and R. Goutarel. 1959. Soc. Chim. de France B. 6: 896.
321. Janot, M. M., K. H. Qui, and R. Goutarel. 1960. Compt. Rend. 250: 2445; 1959. *ibid.* 248: 982.
322. Jayme, G., and G. Rapp. 1959. Das Papier 13: 607.
323. Jayme, G., U. Schwartzkopff, and P. J. Kleppe. 1960. Das Papier 14(5): 186–190.
324. Jurasek, L. 1959. Drev. Vyskum 4(2): 165; For. Abs. 21(3): 483 (1960).
325. Kajanne, P. 1958. Suomen Kemistilehti B 31: 199; C.A. 54: 8072e (1960).
326. Kalnin', I. 1958. Kholodiln Tekhn. no. 6: 57; A.B.I.P.C. 30(7): 906. (1960).
327. Kamlet, J. 1959. Can. Patent 589,057 (Dec. 15).
328. Kanda, T., and H. Kawakami. 1959. J. Japan Wood Research Soc. 5: 64.
329. Kariyone, T., and H. Ageta. 1959. Yakugaku Zasshi 79: 105; C.A. 53: 10031H.
330. Karrer, P., et al. 1958. Angew. Chem. 70(21): 644.
331. Katritzky, A. R., R. A. Y. Jones, and S. S. Bhatnagar. 1960. J. Chem. Soc.: 1950.
332. Kayacik, H. 1959. Istanbul Univ. Orm. Fak. Derg. 9A(1): 11; For. Abs. 21(3): 502 (1960).
333. Khaikina, M. B., and D. M. Vinokurov. 1959. Nauch. Doklady Vyssh Shkoly, Lesoinzh. Delo (1): 240; 1960. Referat. Zhur., Khim. (4): 495.
334. Kharchenko, R. I., and E. K. Tsaregradskii. 1960. Gidroliz. i Lesokhim. Prom. 13(2): 12; C.A. 54: 16828g.
335. Kimura, H. 1959. Japan. Patent 8129 (9/11).
336. King, E. G., and C. Adolphson. 1960. U. S. Patent 2,935,473 (May 3).
337. King, E. G., and C. Adolphson. 1960. U. S. Patent 2,935,504 (May 3).
338. Kishimoto, S., F. Abe, A. Yamaguchi, and G. Unrin-in. 1959. J. Japan Wood Research Soc. 5: 166.
339. Kleinert, T. N., L. M. Marraccini, and E. J. Dostal. 1960. Tappi 43(3): 201–208.
340. Klohs, M. W., F. Keller, and R. E. Williams. 1959. J. Org. Chem. 24: 1829; M. W. Klohs, F. Keller, R. E. Williams, I. M. Toekes, and and G. E. Cronheim. 1959. J. Medicinal and Pharm. Chem. 1:95.
341. Kny, H., and B. Witkop. 1960. J. Org. Chem. 25: 635.
342. Kobayashi, H., S. Nagahama, and S. Akiyoshi. 1959. Bull. Chem. Soc. Japan 32: 202.
343. Kondo, T., H. Imamura, and M. Suda. 1960. Bull. Agr. Chem. Soc. Japan 24: 65; 1959. *ibid.* 23: 233; Yakugaku Zasshi 79: 1298; C.A. 54: 887b, 12185e (1960).
344. Kosilova, E. I., and N. N. Nepenin-1959. Trudy Leningrad Lesotekhn Akad. No. 87: 23–32. Referat. Zhur., Khim. No. 19: 489–490, ABIPC 30:927.
345. Kotasek, Z. 1959. Kozarstvi 9: 35; C.A. 54: 5140g (1960).
346. Kotasek, Z. 1959. Leather Mfr.: 80.
347. Kotasek, Z., and F. Langmaier. 1958. Veda a vyzkum v prumyslu kozedelnem 4: 5; C.A. 53: 19045h (1959).
348. Krakauer, E., J. Frankl, and M. Lewin. 1959. Israel. Res. Council B 8A (3): 126.
349. Kratzl, K. 1959. See Reference 351, page 247.
350. Kratzl, K., and G. Billek. 1959. Monatsh. Chem. 90: 536.
351. Kratzl, K., and G. Billek. 1959. Proceedings of the Fourth International Congress of Biochemistry, Vienna, 1–6 September 1958. V. II. Symposium II. Biochemistry of wood. Pergamon Press, New York, 285 p.
352. Kratzl, K., and H. Faigle. 1959. Monatsh. Chem. 90: 768.
353. Kratzl, K., and J. Gratzl. 1960. Holzforsch. u. Holzverwert. 12: 8.
354. Kratzl, K., W. Kisser, A. Graf, and G. Hofbauer, 1959. Monatsh. Chem. 90: 526.
355. Kratzl, K., W. Kisser, J. Gratzl, and H. Silbernagel. 1959. Monatsh. Chem. 90: 771.
356. Kratzl, K., and G. Puschmann. 1960. Holzforschung 14: 1.
357. Krebs, K. G., and E. Griesinger. 1960. Arzneimittel–Forsch. 10: 32; C.A. 54: 10073f.
358. Kremers, R. E. 1959. Ann. Rev. Plant Physiol. 10: 185.
359. Krjsinsky, B. J., and V. A. Vysotskaja. 1958. "Producing acetic acid by oxidizing wood with air or pure oxygen." Gidrol. Lesohim. Prom. 11(5): 7–10.
360. Kubota, T. T., Kamikawa, T. Tokoroyama, and T. Matsurra. 1960. Tetra. Letters No. 8: 1.
361. Kühnel, E. 1960. Das Papier 14: 96.
362. Kurjan, H. L. 1960. U. S. Patent 2,928,765 (3/15).
363. Kusomoto, M. 1959. J. Japan. Tech. Assoc. Pulp Paper Ind. 13: 709.
364. Labler, L., and F. Sorm. 1960. Chem. and Ind.: 935; Coll. Czech. Chem. Communis. 25: 265; 1959. *ibid.* 24: 2975, 4010; A. Kasal, V. Cernv, and F. Sorm. 1960. *ibid.* 25: 927; V. Cerny and F. Sorm. 1959. *ibid.* 24: 4015; C.A. 54: 2420g, 6816g, 8898d, 13174d (1960).
365. Lagergren, S., and B. Lunden. 1959. Pulp Paper Mag. Can. 60(11): T338-341, T345.
366. Laidlaw, R. A., and G. A. Smith. 1959. Chem. and Ind.: 1604.
367. Laird, W., F. S. Spring, and R. Stevenson. 1960. J. Am. Chem. Soc. 82: 4108.
368. Lamberton, J. A. 1959. Austral. J. Chem. 12: 224.
369. Lamberton, J. A. 1959. Austral. J. Chem. 12: 234.
370. Lane, P. H. 1960. "Wood carbonization in kilns," Forest Products Jour. 10(7): 344–348.
371. Larsson, S. E., and L. Selleby. 1960. Svensk Papperstidn. 63: 606.
372. Lasserre, R. 1959. B. de l'Assoc. Franc. des Chim. des Indus. du Cuir et Doc. Sci. et Tech. des Indus. du Cuir 21(9): 163, 176.
373. Laundrie, J. F. 1959. Forest Prod. Lab. Report 2162, 13 p.
374. Lawrence, R. V. 1959. Tappi 42(10): 867.
375. Lederer, M. "Chomatographic Reviews", Elsevier, N. Y., Vol. 1 (1959), Vol 2 (1960).
376. Lemke, W. A. 1960. U. S. Patent 2,923,693 (Feb. 2).
377. Lewis, D. B. 1959. U. S. Patent 2,918,138 (12/22).
378. Lindberg, J. J. 1958. Suomen Kemistileht. 31B: 35.
379. Lindberg, J. J. 1960. Paperi ja Puu 42(4a): 193.
380. Linkhart, R. 1960. Paper Trade J. 144(27): 28–29.
381. Lipinski, B. 1959. Acta Polon. Pharm. 16: 467; C.A. 54: 10240i (1960).
381a. Liverovskii, A. A., and R. S. Tyul'panov. 1959. Gidroliz. I. Lesokhim. Prom 12(7): 5.
382. Loev, B. 1960. Nature 186(4722): 389.
383. Lyamin, V. A. 1959. "Thermal decomposition of extracted chips," Gidroliz i leshokhim Prom. 12(7): 6–8.
384. Lyamin, V. A. 1959. Nauch. Doklady Vysshei Shkoly, Lesoinzhener. Delo. no. 1: 251.
384a. Lyamin, V. A., and N. A. Bol'shakova. 1959. Izvest. Vsshikh Vcheh. Zevendenii, Lesnoi Zur. 2(4): 157.
385. McCully, C. R. 1960. U. S. Patent 2,926,146 (2/23).
386. McGimpsey, J. R., and J. Murray. 1960. J. Appl. Chem. 10: 340.
387. McKee, R. H. 1960. Paper Ind. 42(4): 255–257, (6): 412–413.
387a. McKee, R. H., and A. D. Merrill. 1959. Canad. patent 586,705 (11/10).
388. McLean, J., and W. E. Watts. 1960. J. Org. Chem. 25: 1263.
389. McMullen, A. 1960. Nature 185 (4706): 103; 1959. Biochem. J. 72: 545.
390. McMurry, T. B. H., and C. Y. Theng. 1960. J. Chem. Soc.: 1491.
391. Maheas, M. R. De. 1959. Compt. Rend. 249(18): 1799.
391a. Malkov, A. M., and Y. I. Marek. 1958. U.S.S.R. patent 114,200 (7/30).
392. Manskaja, S. M. 1959. See Reference 351, page 215.
393. Manske, R. H. F. 1960. "The Alkaloids", Vols. VI and VII, Academic Press, N. Y.; see also E. Leete, J. Am. Chem. Soc. 82: 4754.
394. Manson, D. W. 1960. Tappi 43: 59
395. Marel, H. W. van der. 1960. Plant and Soil 12(1): 5.

396. Marques, S. 1960. Rev. Brasil. Quim. (Sao Paulo) 49: 54.

397. Marshall, H. B., and M. Krizsan. 1959. Can. Patent 578,945 (July 7).

398. Martin, J. S., F. A. Simmonds, and D. J. Fahey. 1960. Forest Prod. Lab. Report 2181, 11 p.

399. Marton, M. J. 1959. See Reference 351, page 154.

400. Mason, A. C., and A. B. Whitfield. 1960. J. Hort. Sci. 35: 34.

401. Mathieu, J.–P., and Janot. 1959. "Optical Rotatory Power. IV. Alkaloids", Pergamon Press, N. Y.

402. Matsugu, T., and H. Shiraiwa. 1959. J. Japan Tech. Assoc. Pulp Paper Ind. 13: 371, 378.

403. Mayer, W., et al. 1959. Naturwissenschaften 46: 206, 669.

404. Mednikov, M. A., E. V. Ushkova, and N. N. Golubeva. 1959. Trudy Leningrad. Lesotekhn. Akad. no. 87: 39; A.B.I.P.C. 30(7): 889 (1960).

405. Mehta, A. C., and T. R. Seshadri. 1959. J. Sci. Ind. Res. 18B: 24; C.A. 53: 21919g.

406. Meinhold, T. F., and J. K. Russell. 1959. Chem. Processing 22(10): 32, 36.

407. Mergen, F. 1959. Botan. Gaz. 121: 32.

408. Messmer, M. K. 1959. Deut. Apoth.-Ztg. 99(39): 972.

409. Metelkin, A. I., S. A. Kuraitis, and S. K. Golubeva. 1959. Izvest. Vysshikh Ucheb. Zavedenii, Tekhnol. Legkoi Prom. No. 6: 52.

410. Meyerhoff, G. 1959. Naturwiss. 46: 143.

411. Mian, A. J., and T. E. Timell. 1960. Tappi 43: 775; 138th Natl. ACS meeting, New York, 9/11, p. 3E of abstracts; 1959. Chem. and Ind.: 1552; 1960. Canad. J. Chem. 38: 1191.

412. Mihai, P. 1958. Rev. chim. (Bucharest) 9: 255: C.A. 54: 7193h (1960).

413. Miller, R. W., and W. G. van Beckum. 1960. Forest Prods. J. 10: 193.

414. Mills, G. S. 1959. Can. Patent 580,057 (July 21).

415. Mills, G. S., and H. E. Haxo, Jr. 1959. U. S. Patent 2,906,718 (Sept. 29).

416. Mills, J. F. D., and S. C. Nyburg. 1960. J. Chem. Soc.: 1458; G. F. Smith and J. T. Wrobel. *ibid.*: 1463.

417. Millstein, H., and K. Norkved. 1960. Norsk Treteknisk Institutt., Oslo, Meddel. no. 14 (June).

418. Milogradova, E. I. 1958. In Vsesoiuznoi Soveshcanie po Rastitel'nym Resursam SSSR, Leningrad, 1954. Sostoianie i perspektivy izucheniia rastitel'nykh resursow SSSR, P 411. Moskva, Akademiia Nauk SSSR.

419. Mirov, N. T. 1959. Atlantic Mon. 204(3): 60.

420. Miyazaki, M., and M. Yasue. 1959. J. Japan Wood Res. Soc. 5: 74; M. Yasue, and M. Miyazaki. 1959. *ibid.* 5: 81.

421. Mladek, M. F. Bencat, and A. Blazej. 1959. Kozarstvi 9: 323; C.A. 54: 10362 (1960).

422. Mondon, A., and K. F. Hansen. 1960. Tetra. Letters No. 14: 5; A. Mondon. 1959. Ann. 628: 123.

423. Monsolud, M. R., and P. V. Bawagan. 1957. "Charcoal production and briquetting." Forest Leaves. Philippines, 10(1): 23–26, 30.

423a. Mori, K., K. Kai, S. Fujii, and Y. Ono. 1958. Parupu Kami Kogyo Zasshi 12: 740.

424. Mors, W. B., O. R. Gottlieb. 1959. Anais assoc. brasil. quim. 18: 185; O. R. Gottlieb, M. T. Magalhaes, and W. B. Mors. *ibid.* 18: 37; W. B. Mors, O. R. Gottlieb, and I. de Vattino. Nature 184 (Suppl. no. 20): 1589; C.A. 54: 2662g, 12181i (1960).

425. Mukherjee, S. N., and V. K. Kulshrestha. 1959. J. Polymer Sci. 39(135): 552; S. Mukherjee, and A. N. Shrivastava. Indian Acad. Sci. Proc. Sect. A 50(6): 374.

426. Mundell, P. M. 1960. Univ. Microfilms L. C. Card No. Mic 59–5365; O. M. Windrath. *ibid.* Mic 59–6659; Dissertation Abstr. 20: 2567, 2571.

427. Murakami, K., and I. Tachi. 1960. J. Japan Wood Research Soc. 6: 16.

428. Murata, T., and N. Takamura. 1959. J. Japan Wood Res. Soc. 5: 194.

429. Murti, V. V. S., S. Neelakantan, T. R. Seshadri, and B. Venkataramani. 1959. J. Sci. and Indus. Res. 18B(9): 367; C.A. 54: 7663g (1960).

430. Nair, G. V., and E. von Rudloff. 1960. Canad. J. Chem. 38: 177; 1959. *ibid.* 37: 1608.

431. Nakano, J., K. Hirakawa, A. Ishizu, A. Kobayashi, and N. Migita. 1959. J. Japan Wood Research Soc. 5: 50.

432. Nakano, J., and C. Schuerch. 1960. J. Am. Chem. Soc. 82: 1677.

433. Nambiayar, V. P. N. 1960. Forest Prods. J. 10: 48; see also Nambiayar. 1959. Bull. Central Leather Res. Inst., Madras 6: 219; C.A. 54: 10365a (1960).

434. Nawa, H. 1959. Japan. Patent 10,472 (12/1): C.A. 54: 18598e (1960).

435. Nayar, S. L., and B. S. Bisht. 1959. J. Sci. Industr. Res. India 18C(1): 15.

436. Nayudamma, Y., J. B. Rao, and K. N. S. Sastry. 1959. Bull. Central Leather Res. Inst., Madras 5: 495; C.A. 54: 2795c (1960).

437. Neish, A. C. 1959. Can. J. Botany 37: 1085.

438. Neuss, N. 1959. J. Org. Chem. 24: 2047.

439. Neuss, N., and N. J. Cone. 1959. Experientia 15: 414.

440. Nichols Engineering and Research Corp., 70 Pine St., New York, N. Y.

441. Nickell, L. G. 1959. Econ. Bot. 13(4): 281.

442. Nishida, K., K. Kuroki, and T. Ono. 1959. J. Japan. Tech. Assoc. Pulp Paper Ind. 13: 800, 854; A.B.I.P.C. 30: 1154 (1960).

443. Nord, F. F., and W. J. Schubert. 1959. Experientia 15: 245.

444. Nord, F. F., and W. J. Schubert. 1959. See Reference 351. page 189.

444a. Odincovs, P., V. Kalnina, and C. A. Sobolenskii. 1959. Trudy Inst. Lesokhoz. Problem Akad. Nauk Latv. S.S.R. No. 17: 53.

445. Odintsov, P. N. 1959. Trudy Inst. Lesokhoz. Problem i Khim. Drevesiny 17: 3; 1960. Referat. Zhur. Khim. (3): 516.

446. Ogiwara, Y., and I. Shimoda. 1959. J. Soc. Textile and Cellulose Ind. Japan 15(12): 972–979.

447. Okahara, K., and S. Taniguchi. 1960. Osaka Shiritsu Daigaku Igaku Zasshi 9: 441; S. Tarriguchi. ibid.: 445; C.A. 54: 17580c.

448. Okamura, H., and Y. Iszuka. 1960. J. Japan. For. Soc. 42: 36; 1959. *ibid.* 41: 502.

449. Okamura, H., and Y. Iizuka. 1960. J. Japan. For Soc. 42: 309.

450. Ondetti, M. A., and V. Deulofen. 1960. Tetra. Letters No. 1:18.

451. Ora, A. 1959. Paperi ja Puu 41: 559.

452. Orazi, O. O., and R. A. Corral. 1960. Rev. farm. (Buenos Aires) 102: 7.

452a. Oshima, M. 1959. Annual Report No. 8, Noguchi Institute, Tokyo, July.

453. Ourisson, G., et al. 1959. Compt. Rend. congr. intern. chim. Ind., 31°, Liege 1958 (Pub. as Ind. chim. belge, Suppl.) 2: 601; C.A. 54: 4659h (1960).

454. Pacheco, H., and A.–M. Brachet. 1960. Compt. Rend. 250: 1106.

455. Pachter, I. J., R. F. Raffauf, G. E. Ullyot, and O. Ribeiro. 1960. J. Am. Chem. Soc. 82: 5187.

456. Pachter, I. J., and G. Suld. 1960. J. Org. Chem. 25: 1680.

457. Painter, T. J., and C. B. Purves. 1960. Tappi 43: 729.

458. Pappo, R. 1959. U. S. Patent 2,913,455 (11/17); R. Pappo, and J. S. Baran. U. S. Patent 2,912,432 (11/10).

459. Paris, R. R., and M. Durand. 1959. Ann. pharm. franc. 17: 593; C.A. 54: 9207g (1960).

460. Paris, R. R., and R. Letouzey. 1957. J. Agr. Trop. et botan. appl. 4: 31; For. Abs. 21(2): 324 (1960).

461. Pearl, I. A. 1959. Can. Patent 580,853 (Aug. 4).

462. Pearl, I. A., and D. L. Beyer. 1959. Forest. Prods. J. 9: 381.

463. Pearl, I. A., and D. L. Beyer, 1959. Tappi 42: 800.

464. Pearl, I. A., and D. L. Beyer. 1960. Tappi 43: 568,611; 138th Natl. ACS meeting, New York, 9/11, p. 4E of abstracts; I. A. Pearl. 1959. Canad. Patent 580,853 (8/4).

465. Pearl, I. A., D. L. Beyer, and D. Laskowski. 1959. Tappi 42: 849.

466. Pearl, I. A., D. L. Beyer, D. Laskowski and D. Whitney. 1960. Tappi 43: 757

467. Pearl, I. A., and J. W. Rowe. 1960. Forest Prods. J. 10: 91.

468. Peckham, J. R., and M. N. May. 1960. Tappi 43(1): 45–48.

469. Peel, A. J., and P. E. Weatherley. 1959. Nature 184 (Suppl. No. 25): 1955.

470. Pepper, J. M. 1959. Tappi 42: 793.

471. Pepper, J. M., P. E. T. Baylis, and E. Adler. 1959. Can. J. Chem. 37: 1241.

472. Pigulevskii, G. V., and V. G. Kostenko. 1959. Doklady Akad. Nauk. SSSR 128: 305; C.A. 54: 7777c (1960).

473. Pillay, P. P., and K. M. Iyer. 1959. Bull. Research Inst. Univ. Kerala Ser. A.6(1): 21; C.A. 54: 16746e (1960).

474. Plachenov, T. G., S. I. Sukhanovskii, M. I. Chudakov, and E. I. Akhmina. 1958. Trudy Inst. Lesokhoz. Problem Akad. Nauk Latv. S.S.R. 16: 89.

475. Plouvier, V. 1960. Compt. Rend. 250 (9): 1721.

476. Plouvier, V. 1960. Compt. Rend. 250: 594; C.A. 54: 16547g.

477. Plouvier, V. 1960. Compt. Rend. 251 (1): 131.

478. Polčin, J. 1957. Sbornik Vyzkumnych. Prací z Oboru Celulosy a Papíru 2: 173.

479. Polčin, J. 1960. Czech. Patent 85, 957; Referat. Zhur., Khim. (8): 565.
480. Polishchuk, L. K. 1958. Visnik Kiiv. Univ., Ser. Biol. no. 1: 53; C.A. 54: 16556f (1960).
481. Polonsky, J. 1959. Bull. soc. chim. France: 1546; C.A. 54: 10071b (1960).
482. Polonsky, J., and E. Lederer. 1959. Bull. soc. chim. France: 1157.
483. Popli, S. P., M. L. Dhar, and P. R. Bhandari. 1958. Chemotherapy, Proc. Symposium Central Drug Research Inst. Lucknow: 153; C.A. 54: 11065c (1960).
484. Prager, R. H., E. Ritchie, and W. C. Taylor. 1960. Austral. J. Chem. 13: 380.
485. Pravdin, L. F. 1959. Akad. Nauk SSSR, Bot. Inst. Trudy, Ser. 6 Introd. Rast. i Zelenoe Stroitel'stvo 7: 394.
486. Preusser, H. M. 1960. Can. Patent 591,596. (1/26).
487. Price, J. R. 1959. Austral. J. Chem., 12: 458.
488. Pridham, J. B. 1960. "Phenolics in Plants in Health and Disease", Pergamon Press, N. Y.
489. Prista, L. N., and A. C. Alves. 1958. Gracia orta 6: 679; C.A. 53: 20792a (1959).
490. Puisieux, F., R. Goutarel, M. M. Janot, and A. Le Hir. 1959. Compt. Rend. 249: 1369; M. M. Janot, R. Goutarel, A. Le Hir, and F. Puisieux. 1959. *ibid.* 248: 108; F. Puisieux A. Le Hir, R. Goutarel, M. M. Janot, and J. Le Men. 1959. Ann. pharm. franc. 17: 626; M. M. Janot, R. Goutarel, A. Le Hir, and Bejar. 1958. *ibid.* 16: 38.
491. Pulp Chemicals Assoc. 1959. Tappi 42(6): 60A, 62A, 64A, 66A.
492. Pyc. W. 1958. Budown. weijskie 10(11): 21; 1959. Referat. Zhur. Khim. (14): 350.
493. Raffauf, R. F., and M. B. Flagler. 1960. Econ. Bot. 14: 37.
494. Rao, K. V., and P. K. Bose. 1959. J. Indian Chem. Soc. 36: 358; Sci. and Culture (Calcutta) 24: 486; C.A. 53: 20124f; 54: 9291a.
495. Rapi, G., and E. Orlandi. 1959 Contr. sci.-prat. migl. Conosc. Util. Legno, Firenze Fasc. 2(2): 1.
496. Rapoport, H., and K. G. Holden 1960. J. Am. Chem. Soc. 82: 4395
497. Rapoport, H., et al. 1960. J. Am Chem. Soc. 82: 4404; 1959. *ibid.* 81: 3166.
498. Ras, J. B., K. N. S. Sastry, and Y. Nayudamma. 1959. Bull. Central Leather Research Inst., Madras 6: 59; C.A. 54: 4013a (1960).
499. Räsänen, R., and L. Luotonen. 1960 Paper Mill News 83(3): 16–17.
500. Raszejowa, W., and K. Szpunarowna. 1959. Acta Polon. Pharm. 16: 131; C.A. 53: 20303e.
501. Renner, V. 1959. Experientia 15: 185.
502. Renner, V., D. A. Prins, and W. G. Stoll. 1959. Helv. Chim. Acta 42: 1572.
503. Reznik, H. 1959. See Reference 351. page 70.
504. Reznik, H., and K. Egger. 1960. Z. Naturforsch. 15b: 247; C.A. 54: 19866i.
505. Riehm, T. 1959. Canadian patent 585,424 (10/20).
506. Ritchie, E., W. C. Taylor, and D. V. Willcocks. 1960. Austral. J. Chem. 13: 426.
507. Rivero., A. M., and M. G. Mortola de Solari. 1957. Quim. ind. (Montevideo) 3(2): 123.
508. Roberts, J. R., and A. S. Gregory. 1959. Can. Patent 581,605 (8/18); see U. S. Patent 2,832,765.
509. Robinson, R. 1959. Tetra. Letters No. 18: 14.
510. Roff, J. W., and E. I. Whittaker. 1959. Canad. J. Botony 37: 1132.
511. Roscoe, C. W., and N. A. Hall. 1960. J. Am. Pharm. Assoc. Sci. Ed. 49: 108
512. Rösler, H. J. 1959. Z. Angew. Geol. 5: 565.
513. Roth, L., et al. 1960. "Barkers and Barking of Pulpwood", Institute of Paper Chemistry, Appleton, Wisc. Bibliographic ser. no. 190.
514. Roux, D. G. 1959. Das Leder 10: 177; J. Amer. Leather Chem. Assoc. 54(11): 614; Leather Mfr.: 30.
515. Roux, D. G., and S. R. Evelyn. 1960. Biochem. J. 76(1): 17.
516. Roux, D. G., and A. E. Maihs. 1960. Biochem. J. 74: 44.
517. Roux, D. G., and A. E. Maihs. 1960. J. Chromatography 4: 65.
518. Rowe, J. W., H. L. Hergert, E. Wagner, and W. Nickles. Unpublished results.
519. Rudman, P. 1959. Holzforschung 13(4): 112.
520. Rudman, P., and E. W. B. DaCosta. 1959. Institute of Wood Science J. 3: 33.
521. Rumyantseva, L. A. 1958. Aptechnoe Delo 7(5): 39: C.A. 54: 7074 (1960).
522. Runeberg, J. 1960. Acta Chem. Scand. 14: 797; C. Pilo, and J. Runeberg. *ibid.*: 353.
523. Russell, J. K., and G. J. Byrd. 1959. U. S. Patent 2,901,429 (Aug. 25).
524. Ruzicka, L. 1959. Proc. Chem. Soc. London: 341.
525. Ryabinin, A. A., and I. G. Matyukhina. 1959. Doklady Akad. Nauk SSSR 129: 125; I. G. Matyukhina and A. A. Ryabinin. *ibid.* 131: 316; C.A. 54: 8889b, 15431g (1960).
526. Sadykov, A. S., and Y. I. Pakanaev. 1959. Zhur. Obshchei. Khim. 29: 2439; C.A. 54: 10240g (1960).
527. Sakai, A. 1960. J. Japan For. Soc. 42: 97.
528. Sakata, K., J. Kishimoto, and H. Saeki. 1959. Res. Bull. Exp. For. Hokkaido Univ. 20(1): 119 A.B.I.P.C. 30(6): 812 (1960).
529. Saltsman, W., and K. A. Kuiken. 1959. Tappi 42(11): 873.
530. Salvesen, J. R. 1959. Forest Prods. J. 9: 25A.
531. Samuels, R. M. 1960. Paper Mill News 83(13): 52.
532. Sandermann, W. 1960. "Naturharze–Terpentinoel–Talloel. Chemie und Technologie", Springer–Verlag, Berlin.
533. Sandermann, W., and H. Dietrichs. 1959. Holzforschung 13: 137.
534. Sandermann, W., H. H. Dietrichs, and M. Puth. 1960. Holz Roh–u.-Werkstoff 18: 63.
535. Sandermann, W., and M. Rothkamm. 1959. Holz Roh–u.–Werkstoff 17-(11): 433.
536. Sangster, A. W. 1960. J. Chromatography 3(1): 92.
537. Sapotnitskii, S. A., and A. G. Moskaleva. 1959. Zhur. Priklad. Khim. 32(7): 1586–1590. ABIPC 30: 929.
538. Savard, J. 1959. 8th Sess. FAO Tech. Panel Wood Chem., Wiesbaden, No. FAO/WCP/59–3.
539. Sayward, J. M. 1960. Northeastern Logger 8(8): 14.
540. Schafer, E. R., A. Hyttinen, and J. S. Martin. 1960. Forest Prod. Lab. Report 2185, 15 p.
541. Scheuer, P. J., and T. J. Horigan. 1959. Nature 184 (Suppl. No. 13): 979.
542. Schmitt, O. T. 1959. Leather Mfr.: 32.
543. Schmutz, J., and H. Lehner. 1959. Helv. Chim. Acta 42: 874; W. I. Taylor, N. Raab, H. Lehner, and J. Schmutz. *ibid.* 42: 2750 G. B. Marini–Bettolo and J. Schmutz. *ibid.* 42: 2146; P. C. Ferreira, G. B. Marini–Bettolo, and J. Schmutz. Experientia 15: 179; G. B. Marini–Bettolo, and P. C. Ferreira. Ann. chim. (Italy) 49: 869.
544. Schöning, A. G., and G. Johansson. 1959. Svensk Papperstidn. 62: 646.
545. Schubert, W. J., and S. N. Acerbo. 1959. Arch. Biochem. Biophys. 83: 178.
546. Schwarz, H. 1959. Seifer–Ole–Fette-Wachse 85 (24): 744.
547. Seikel, M. K., D. J. Holder, and R. Birzgalis. 1959. Arch. Biochem. Biephys. 85: 272; C.A. 54: 9009d (1960).
548. Seitz, G. 1959. Naturwissenschaften 46: 263.
549. Selleby, L. 1960. Svensk Papperstidn. 63: 81.
550. Sengupta, P., S. N. Choudhuri, and H. N. Khastgir. 1960. Tetrahedron 10: 45; P. Sengupta, S. K. Sengupta, and H. N. Khastgir. *ibid.* 11: 67.
551. Seshadri, T. R., and B. Venkataramani. 1959. J. Sci. and Indus. Res 18B(6): 261; C.A. 54: 17389 (1960).
552. Sharkov, V. I., I. I. Korol'kov, and E. N. Garmanov. 1958. Sbornik Trudov Vsesoyuz. Nauch.–Issledoval. Inst. Gidroliz. i Sulfitno–Sprit. Prom 6: 5.
553. Sharma, A. K. 1959. Nature 184-(4692: 1083; A. K. Sharma, and A. K. Bol. 1959. Portugaliae Acta Biol., Ser. A 6: 45; C.A. 54; 17566i (1960).
554. Shasha, B., and J. Leibowitz. 1959. Nature 184 (Suppl. No. 26): 2019.
555. Shaw, F. H. (Chairman). 1959. "A Phytochemical Register of Australian Plants", Vol I, C.S.I.R.O., Melbourne; J. J. H. Simes. 1959. Bull. Commonw. Sci. Industr. Res. Organ. Austral. no. 281.
556. Shimazono, H. 1959. Arch. Biochem. Biophys. 83: 206.
557. Shook, R. E. 1959. Paper Mill News 82(45): 22.
558. Shteinbok, S. D. 1958. Sostoyanie i. Perspektivy Izuchen. Rastitel. Resursov S.S.S.R. Sbornik: 289; C.A. 54: 20192g (1960).
559. Siegel, S., P. Frost, and F. Porto. 1960. Plant Physiol. 35: 163.
560. Siegel, S. M., B. LeFevre, Jr., and R. Borchardt. 1958. Am. J. Sci. 256: 48.
561. Silver Engineering Corp., Denver, Colo.
562. Simionescu, C. 1958. Bul. inst. politeh. Iași [N.S.] 4(8), no. 3–4: 203.
563. Simmonds, F. A., and G. H. Chidester. 1960. Forest Prod. Lab. Report 2189, 42 p.
564. Simmons, F. C. 1960. "Revival in the charcoal industry," The New York State Conservationist, Apr.–May.
565. Sisido, K., and H. Nozaki. 1960. J. Org. Chem. 25: 874.
566. Sisley, L. J. 1959. U. S. Patent 2,876,698 (3/10).
567. Skrigan, A. I., and T. V. Murashkevich. 1958. Doklady Akad. Nauk Belorus. S.S.R. 2: 308; 1959. Referat. Zhur., Khim. (11): 432.
568. Skrigan, A. I., T. V. Murashkevich, A. I. Kozlov, and A. N. Minin. 1958. Trudy Inst. Lesokhoz. Problem Akad. Nauk Latv. S.S.R. 16: 109.

569. Smirnov, P., and V. S. Sidarov. 1960. Zhur. Priklad. Khim. 33: 1192; C.A. 54: 18955b.
570. Smith, C. R. 1959. "Charcoal for barbecuing meats," U. S. patent 2,916,-365.
571. Smith, K. N. 1959. Tappi 42: 869.
572. Smith, L. V., and E. Zavarin. 1960. Tappi 43: 218.
573. Smolanka, I. L., and G. S. Chek'rii. 1960. Sedroliz. i Lesokhim. Prom. 13 (2): 11.
574. Sohn, A. W. 1960. Can. Patent 593,457 (March 1).
575. Sohn, A. W. 1960. U. S. Patent 2,921,879 (1/19).
576. Sokolov, P. D. 1959. Bot. Z. 44(9): 1328; For. Abs. 21(2): 323 (1960).
577. Sokolova, A. A., B. D. Bogomolov, F. A. Krupkina, G. S. Brodskii, and N. V. Afanas'eva. 1958. Nauch. Doklady Vysshei Shkoly, Khim. i Khim. Tekhnol. (3): 556; 1959. Referat. Zhur., Khim. (21): 492.
578. Sondheimer, F., and A. Meisels. 1960. Tetrahedron 9: 139.
579. Sosnin, A. E. 1958. Izvest. Vyssh. Ucheb. Zaved., Lesnoĭ Zhur. (5): 156.
580. Sperry, R. L. 1959. U. S. Patent 2,894,940 (July 14).
581. Spitz, R. J. 1959. Nav. Stores Rev. Internatl. Ybk.: 14, 27.
582. Stafford, H. A. 1960. Plant Physiol. 35: 108.
583. Steinegger, E., and A. Brantschen. 1959. Pharm. Acta Helv. 34: 334; C.A. 54: 7064h (1960).
584. Stetter, H., and R. Lauterbach. 1959. Angew. Chem. 71: 673.
585. Stockman, L. G. 1960. Tappi 43(2): 112–120.
586. Stoianov, V., and D. Koev. 1959. Bulgar. Akad. na Nauk. Inst. za Gorata. Izv. 4: 261.
587. Strub, C., I. Iarosinschi-Drabic, and C. Maga. 1958. Bul. Inst. politeh. Iasi (8) 4: 229; A.B.I.P.C. 30(8): 1028 (1960).
588. Suchy, M., V. Herout, and F. Sorm. 1959. Czech. Patent 88,321 (1/15); C.A. 54: 8771c (1960).
589. Suginome, H. 1959. J. Org. Chem. 24: 1655; 1960. Tetra. Letters No. 19: 16.
590. Sukacev, V. N., and L. F. Pravdin. 1958. Trud. Inst. Les. No. 46: 153.
591. Sullivan, F. E. 1959. J. Am. Oil Chemists' Soc. 36(3): 124; Anon. Chem. Eng. 66(5): 84, 86.
592. Sumarokov, V. P. 1917–1957. "The main results from the study of the composition and utilization of pitch obtained in pyrolysis and gasification of wood," Gidroliz. i heshokhim. Prom 10. No. 7. 21–24.
593. Sutherland, M. D., L. J. Webb, and J. W. Wells. 1960. Austral. J. Chem. 13: 357.
594. Suzuki, I., and S. Nagano. 1959. J. Japan Tech. Assoc. Pulp Paper Ind. 13: 716.
595. Swartz, J. N. 1960. Paper Trade J. 144(41): 44–50.
596. Swenson, L. K. 1959. U. S. Patent 2,916,355 (Dec. 8).
597. Tachi, I., and K. Murakami. 1959. J. Japan Wood Research Soc. 5: 101.
598. Takahashi, K., Y. Tanabe, and H. Kano. 1959. Kanazawa Daigaku Yakugakubu Kenkyu Nempo 9: 52.
599. Takahashi, T. 1959. J. Japan Wood Res. Soc. 5: 185.
600. Tanaka, J., and T. Kondo. 1959. J. Japan. Wood Research Soc. 5: 105.
601. Tardif, J. W. 1959. Appita 13(2): 58.
602. Tayeau, F., R. Nivet, J. Marquevielle, and M. Dumas. 1958. Bull. soc. chim. biol. 40: 671; C.A. 52: 16453b.
603. Thomas, A. F., and J. M. Muller. 1960. Experientia 16(2): 62.
604. Thomas, R. J. 1959. Forest Prods. J. 9(8): 266.
605. Thompson, W. E. 1959. Can. Patent 575,408 (5/5).
606. Thompson, W. E. 1959. Can. Patent 583,016 (Sept. 8).
607. Tishchenko, D. V., and I. D. Fedorishchev. 1958. "Treatment of soluble pitch from wood," (Wood Tech. Acad., Leningrad) Gidroliz. i heshokhim Prom. 11, No. 4, 8–11.
608. Tiwari, R. D., and R. K. Gupta. 1959. Current Sci. 28(5): 213.
609. Tomaszewski, M. 1960. Bull. acad. polon sci. Ser. sci. biol. 8: 61; C.A. 54: 19866f.
610. Tomlinson II, G. H. 1960. Pulp Paper Mag. Can. 61(5): T283–288.
611. Traverso, G. 1958. Gazz. chim. ital. 88: 851; C.A. 54: 454g. (1960).
612. Tsutsui, M., and E. A. Tsutsui. 1959. Chem. Revs. 59: 1031.
613. Tsvetaeva, I. P., and M. K. Yur'eva. 1959. Zhur. Priklad. Khim. 32: 2533; I. P. Tsvetaeva, and A. V. Merkur'eva. *ibid.* 32: 2707; C.A. 54: 9281b, 10317e (1960).
614. Turner, G. H. 1959. U. S. Patent 2,877,165 (3/10).
615. Tyul'panov, R. S. 1957. "Studies and calculations on the thermolysis of wood," Gidrol. lesohim. Prom. 10 (6): 13–14.
616. Tyul'panov, R. S. 1958. Trudy Leningrad Lesotekh. Akod. im. S. M. Kirova No. 80: 59.
617. Umano, S., and S. Kawasaki. 1959. Repts. Govt. Chem. Ind. Research Inst., Tokyo 54: 218.
618. Umano, S., and S. Kawasaki. 1959. Repts. Govt. Chem. Ind. Research Inst., Tokyo 54: 222.
619. U. S. Forest Products Laboratory. 1957. U. S. Forest Products Lab. Rept. No. 1577 (Revised), Madison, Wis.
620. Uschmann, C.. 1959. Can. Patent 586,979 (Nov. 10).
621. Uschmann, C. 1959. Can. Patent 586,982 (Nov. 10).
622. Valenta, Z., A. H. Gray, S. Papadopoulas, and C. Podesva. 1960. Tetra. Letters no. 20: 25.
623. Vethe, A., V. Loras, and F. Loschbrandt. 1960. Norsk Skog 14(5): 167–178.
624. Vil'kova, S. N. 1959. Zhur. Priklad. Khim. 32: 1802.
625. Vişoiu, I. 1960. Celuloză şi hîrtie 9: 73.
626. Voorhees, A., and E. F. Scott. 1959. U. S. Patent 2,899,261 (Aug. 11).
627. Wafer, J. M. 1959. Paper Trade J. 143(48): 30; AT–FA Journal 22(3): 5; 1960. Paper Ind. 41: 707; Tappi 43(4): 12A.
628. Wagenbreth, A. N. 1959. Flora (Jena) 147(1): 164.
629. Waldi, D. 1959. Arch. Pharm. 292: 206.
630. Wall, M. E., et al. 1959. J. Am. Pharm. Assoc. 48: 695.
631. Wardrop, A. B., and D. E. Bland. 1959. See Reference 351, page 92.
632. Wardrop, A. B., and G. W. Davies. 1959. Holzforschung 13: 65.
633. Weiner, J. 1959. "Bibliography of Papermaking and U. S. Patents", Tech. Assoc. Pulp Paper Ind., New York.
634. Weinges, K. 1959. Ann. 627: 229; C. A. 54: 12128e (1960).
635. Weinges, K. 1960. Tetra. Letters no. 20: 1.
636. Weiss, W. J., and R. H. Graves. 1959. Can. Patents 576,739 (5/26), 583,845 (9/22); W. J. Weiss, and W. L. Hall. 1959. Can. Patents 580,504 (7/28), 584,268 (9/29), 584,269 (9/29); see U. S. Patents 2,831,022, 2,856,154, and 2,856,357.
637. Wenkert, E., and V. I. Stenberg. 1960. 137th Natl. ACS meeting. Cleveland, 4/12. p. 36-O of abstracts.
638. Wenkert, E., and A. Tahara. 1960. J. Am. Chem. Soc. 82: 3229.
639. Wethern, J. D. 1959. Canad. Pulp Paper Ind. 12(9): 23.
640. Wiedow, J. C. 1959. U. S. Patent 2,893,913 (July 7).
641. Wiesner, K., and D. E. Orr. 1960. Tetra. Letters No. 16: 11.
642. Wilde, S. A. 1960. Compost Sci. 1(2): 38.
643. Wiley, A. J., and J. M. Holderby. 1960. Pulp Paper Mag. Can. 61(3): T212.
644. Williams, L. O., and C. O. Erlanson, 1959. Quality. Plant. Meter. Veg. 6(2): 114.
645. Williams, R. M., and G. F. Baxter. 1960. U. S. Patent 2,930,772 (3/29).
646. Wilson, A. W. 1960. Pulp and Paper 34(4): 92–96.
647. Wilson, J. W., and D. O'Meara. 1960. Pulp Paper Mag. Can. 61(4): T259–262.
648. Winde, E., M. Sirait, and R. Hänsel. 1959. Pharm. Zenthalle. f. Deut. 98(11): 637; Pharm. Ztg. 104(40): 1056; E. Winde and R. Hänsel. 1960. Arch. Pharm. 293: 556; C.A. 54: 20084g.
649. Wolf, G. 1959. Zellstoff u. Papier 8: 424.
650. Wolinsky, J., and W. Barker. 1960. J. Am. Chem. Soc. 82: 636.
651. Woodard, G. W., and C. L. Lunsford. 1959. Can. Patent 583,794 (Sept. 22).
652. Woodbury, A. M., M. E. Wall, and J. J. Williaman. 1960. 137th Natl. ACS meeting. Cleveland (4/8).
653. Yoneichi, K., and H. Sawada. 1959. Yakugaka Zasshi. 79: 1226.
654. Zavarin, E., A. B. Anderson, and R. M. Smith. 1960. 138th Natl. ACS Meeting, New York, 9/11. p. 4E of abstracts.
655. Zavarin, E., R. M. Smith, and A. B. Anderson. 1959. J. Org. Chem. 24: 1584.
656. Zechmeister, L. 1959. "Progress in the Chemistry of Organic Natural Products", Vol. 17. Springer–Verlag. Vienna.
657. Zenczak, P. 1959. Can. Patent. 582,018 (8/25); W. Burgon, and P. Zenczak. 1960. Can. Patent 594,828 (3/22); see C.A. 54: 15931f.
658. Zieger, E., and O. Blossfeld. 1959. Ges. Abhandl. deut. Lederinst. Freiberg/Sa. No. 14: 139; C.A. 54: 20264b.

Crystallinity of Wood Cellulose Fibers

STUDIED BY X-RAY METHODS[1]

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Crystallinity may increase with age and varies seasonally in juvenile wood. The crystallinity of reaction wood was different from that of normal wood. Crystallinity also increased during incipient decay.

IT HAS BEEN WELL ESTABLISHED that cellulose consists of two regions, known as crystalline and amorphous regions. The former is in the state of relatively perfect, three-dimensional order, which gives rise to selective X-ray diffraction patterns. It has a high resistance to chemical reaction. The amorphous region is in a state of relative disorder, which is characterized and identified by failure to produce definite X-ray diffraction patterns. The relative quantity of these two regions, in terms of degree of crystallinity, is highly variable, and depends upon the types and sources of cellulose. It has been shown by various workers that the degree of crystallinity is one of the most important factors affecting the physical and chemical properties of native cotton cellulose as well as regenerated cellulose fibers. These properties are summarized in Table 1.

Table 1.—EFFECT OF INCREASING CRYSTALLINITY ON PROPERTIES OF CELLULOSE FIBERS (7, 13)

Increase	Decrease
density	moisture regain
Young's modulus	dye sorption
tensile strength	chemical reactivity
alpha-cellulose content	swelling
dimensional stability	elongation
hardness	flexibility
	toughness

Extensive research has been done on crystallinity, mostly with pulp or cotton cellulose, to determine its effect on physical and chemical properties. A limited number of workers have studied the crystallinity of whole wood, yet it may be an important factor directly or indirectly affecting wood properties and quality.

The purpose of this paper is to record quantitatively 1) the variation with age in crystallinity of pulp from a young tree; 2) the degree of crystallinity of summerwood pulp as compared with that of springwood pulp; 3) the crystallinity of reaction wood pulp as compared with that of normal wood; and 4) the relationship between crystallinity and decay of wood.

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Experimental Method

Materials: The study consisted of three parts, as follows:

Part I. Crystallinity of pulp from normal wood of various ages and seasons; that is, springwood and summerwood.

Part II. Crystallinity of pulp from reaction wood (compression wood and tension wood).

Part III. Crystallinity of pulp from wood in various stages of decay by brown-rot fungi.

For Part I, a cross-sectional disc was taken from a 33-year-old tree of western hemlock *(Tsuga heterophyllia* (Rafn.) Sarg.) at 10 feet above the ground. Several small blocks were prepared from the 3rd, 9th, 15th, and 21st growth ring from the pith at a randomly chosen position within each ring. These were separated with a chisel into springwood and summerwood.

The compression wood used in Part II was obtained from an 80-year-old Douglas-fir *(Pseudotsuga menziesii* (Mirb.) Franco). The wood sample consisted of growth rings 15 to 18 inclusive, whereas the normal wood, taken from the diametrically opposite position, consisted of growth rings 13 to 21 inclusive. To obtain the tension wood, a leaning 28-year-old northern black cottonwood *(Populus trichocarpa* Torr. and Gray) was sampled. Tension and normal wood samples, taken at breast height on opposite sides, were of the same age; they included the 20th to 24th rings from the pith.

The decayed wood specimens used in Part III were obtained by exposing sample blocks, matched to those used in Part II, to pure cultures of two brown-rot organisms, *Poria incrassata* and *Poria monticola.* Exposure resulting in a 6 percent weight loss due to *Poria incrassata* was designated at stage A, whereas that which resulted in 15 percent weight loss due to *Poria monticola* was designated as stage B.

Wood pulp and holecellulose samples were prepared for Parts I and II of this study, whereas only holocellulose was used for Part III. Pulp was prepared by treating sample chips with a solution containing equal parts of glacial acetic acid and 30–35 percent hydrogen peroxide at 100° C. for one hour. The pulp was then dried in the open air for several days. Fifty mg. of the air-dried pulp thus prepared were rewetted with water and compressed into a cylinder-type specimen, 15 mm. in length and 2 mm. in diameter, with a glass tube. This type of specimen was used for X-ray method A.

A modification of the chlorite method of Wise and coworkers (23)[2], suggested by Dr. A. P. Yundt (9) was used for preparation of holocellulose. One hundred and fifty mg. of the air-dried holocellulose thus prepared were put into a specially designed compression tube, and a gage pressure of 1000 psi was applied for five minutes by means of a laboratory press. The final disc-type specimen had a diameter of 14 mm. and a thickness of approximately 0.75 mm. This type of specimen was used for X-ray method B.

X-ray Procedure and Evaluation of Crystallinity

Method A: The principle of the Debye-Scherrer powder technique was applied. The radiation used was Cu K alpha ($\lambda = 1.54$ Å) monochromatized by means of a nickel filter. The X-ray machine was operated at a voltage of 45 KV and a current density of 15 MA. An exposure time of 20 minutes proved to be most satisfactory. The procedure was repeated to give three replicates. A densitometer curve was obtained by measuring the optical density of the exposed negative with an electric densitometer. Crystallinity was evaluated as a crystallinity index by the following formula developed by Ant-Wuorinen (2).

$$\text{Crystallinity index} = \left(1 - \frac{100B}{I_{002} - I_{min}}\right) 100$$

where B is the breadth of the 002 peak expressed in radians, I_{002} is the

[1] A 1960 Wood Award entry, based on a thesis for the Master of Forestry degree at the Univ. of B.C. Approved version received for publication Dec. 7, 1960.

[2] Numbers in parentheses refer to the Literature Cited at the end of this paper.

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Table 2.—EFFECTS OF AGE AND SEASON ON CRYSTALLINITY OF WESTERN HEMLOCK WOOD PULP AND HOLOCELLULOSE

Season	Specimen	Crystallinity index —X-ray method A— (wood pulp) 3[1]	9[1]	15[1]	21[1]	Crystallinity ratio —X-ray method B— (holocellulose) 3[1]	9[1]	15[1]	21[1]
Summerwood	1	53.4	55.4	56.3	58.1	54.56	54.88	55.51	55.52
	2	53.3	54.2	57.5	58.0	54.31	54.73	55.28	55.63
	3	53.0	54.9	57.3	56.9				
	av.	53.2	54.8	57.0	57.7	54.44	54.81	55.40	55.58
Springwood	1	53.1	55.0	57.0	56.5	54.31	54.65	55.06	54.89
	2	52.0	54.4	56.3	56.4	54.21	54.76	55.00	55.05
	3	52.2	54.6	56.4	56.2				
	av.	52.4	54.7	56.6	56.4	54.26	54.71	55.03	54.97

[1]Age from pith, years.

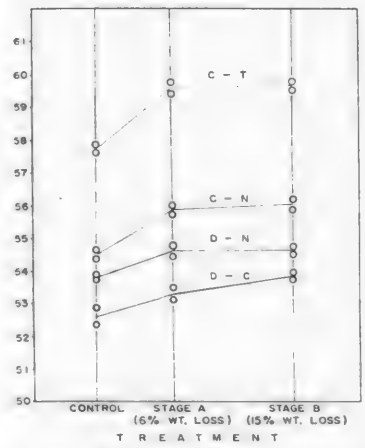


Fig. 2.—Effect of decay and type of wood on crystallinity ratio of holocellulose. C-T: cottonwood tension wood; C-N: cottonwood normal wood; D-N: Douglas-fir normal wood. D-C: Douglas-fir compression wood.

maximum intensity of the 002 peak in arbitrary units, and $I_{min.}$ is the minimum intensity between the 002 and $(101 + 10\bar{1})$ peak in the same arbitrary units.

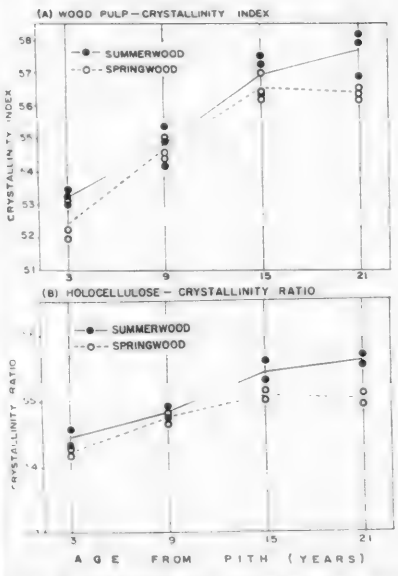


Fig. 1.—Variation of crystallinity with age and season in normal wood.

Method B: A Geiger-counter X-ray spectrometer was used. The same source of X-ray was used as described in method A. The intensity of the diffracted beam registered by the goniometer was recorded automatically by a Brown Recorder. A small correction was made for the background intensity. Only two replications of a single sample were used in this method. Crystallinity was evaluated as crystallinity ratio by the following formula developed by Anker-Rasch and McCarthy (1).

Crystallinity ratio =

$$\frac{I_{(101 + 10\bar{1})}}{I_{(101 + 10\bar{1})} - I_{min.}} \times 100$$

where $I_{(101 + 10\bar{1})}$ is the maximum intensity of the combination $(101 + 10\bar{1})$ peak in arbitrary units, and $I_{min.}$ is as defined above.

Results and Discussion

Part I. The Degree of Crystallinity of Pulp and Holocellulose of Normal Wood: The results shown in Table 2 and Fig. 1 indicate that crystallinity of both wood pulp and holocellulose increases with tree age from the pith to about 15 years, then reaches a more or less constant value. The crystallinity of summerwood pulp and holocellulose is also higher than that of the comparable springwood specimens. These differences in crystallinity are found to be clearly significant when an analysis of variance procedure is applied, as shown in Table 3. Further analysis shows that the difference in crystallinity between the 15th and the 21st growth rings is nonsignificant. This implies that the crystallinity of juvenile whole wood increases with age, whereas that of more mature whole wood is more constant, and exhibits a negligible variation. Maturity in this case is defined as the age at which the curve of crystallinity versus age flattens.

The increase in crystallinity of wood pulp during the immature stage (from the pith to the 15th growth ring) seems to have a constant increment. This means that the apparent degree of crystallinity might be correlated with age. This observation is in good agreement with results obtained by Taniguchi (16).

Wardrop (18) has illustrated that tensile strength of tracheids increases with tree age up to 20 years. Since an increase in tensile strength is usually accompanied by an increase in crystallinity, it is theoretically acceptable that the crystallinity should increase with age. This does not necessarily mean, however, that an increase in tensile strength is solely attributable to an increase in crystallinity. Fibril angle and cellulose molecular chain length distribution are also important in this respect.

It has been shown that Cross and Bevan cellulose content (9, 18) and holocellulose content (24, 25) increase with age for a given period in certain species. Since there is a strong positive correlation between alpha-cellulose and holocellulose content (24), as well as Cross and Bevan cellulose content (9), it may be assumed that the alpha-cellulose content increases with age. If this is true, then the crystallinity can be expected to increase with age, since a cellulose of high alpha-cellulose content always

Table 3.—ANALYSIS OF VARIANCE, CRYSTALLINITY OF SAMPLES IN TABLE 2

Source of variance	D.F.	S.S.	M.S.	F	
(A) Crystallinity index (wood pulp)					
Unit:					
replication	2	0.77	0.385	1.774	N.S.
age	3	69.44	23.147	106.668	***
error	6	1.30	0.217		
Subunit:					
season	1	2.80	2.800	13.462	**
AxS	3	1.07	0.357	1.716	N.S.
error	8	1.66	0.208		
Total	23	77.04			
(B) Crystallinity ratio (holocellulose)					
Unit:					
replication	1	0.011	0.011	0.550	N.S.
age	3	2.251	0.750	37.500	**
error	3	0.059	0.020		
Subunit:					
season	1	0.388	0.388	48.500	**
AxS	3	0.152	0.051	6.375	N.S.
error	4	0.030	0.008		
Total	15	2.891			

**Significant at 1 percent level; ***Significant at 0.1 percent level; N.S. Non significant.

gives a high degree of crystallinity (7).

Data obtained by Wardrop (18) showed that moisture regain of Cross and Bevan cellulose decreased with tree age. This indicates the following two possibilities: (a) Crystallinity might increase with age so that moisture regain would decrease with tree age. (b) The hemicellulose fraction could decrease with tree age. In this instance, moisture regain would also decrease with tree age.

It has been noted by Rånby (4) that the lower lattice order of wood cellulose, as compared with that of cotton cellulose, could be due to the presence of other monosaccharides in the cellulose chains. Conrad and Scroggie (7) also claimed that an increase in accessibility will occur when relatively low-molecular-weight materials such as beta and gamma cellulose are present. If these workers are correct, then holocellulose near the pith, which contains a higher amount of hemicellulose, as revealed by Zobel and co-workers (25), should give a lower crystallinity. This is in good agreement with the present results. Thus both of the above-mentioned possibilities are acceptable in theory.

The present results are in disagreement with those obtained by Preston and co-workers (14), on Cross and Bevan cellulose. The time of delignification required to reach an end point for different samples is not constant if the lignin content is variable for those samples. If a sample taken near the pith is assumed to have a higher lignin content than one near the bark, then the time of delignification for the former should be relatively long, and the duration of recrystallization of cellulose chains during the delignification would be considerably prolonged. Consequently, the cellulose thus prepared might give higher crystallinity as compared with that from the bark, even though the initial crystallinity was identical.

The observation that summerwood has higher crystallinity than springwood is in good agreement with Holzer and Lewis (8), and Lindgren (10). The difference in crystallinity between summerwood and springwood is smaller than was expected. This may be because the summerwood sample contained about 50 percent of springwood tracheids because of inaccuracy in dissection due to the anatomical characteristics of the wood of western hemlock.

The mechanism of variability of crystallinity with age and season is unknown, because inadequate information is available about the mechanism of the formation of cellulose crystallites and fibrils in the cell wall. Wardrop (19) has proposed that crystallization of cellulose is facilitated by the absence of lignin, based on the fact that cellulose displays its highest crystallinity value when the lignin content is low. If this hypothesis is correct, summerwood cellulose should be more highly crystallized than springwood cellulose because the relative proportion of cellulose to lignin in the summerwood has been found to be higher than that of springwood (15, 22). Crystallinity might also increase with age in juvenile wood, since the cellulose content has been shown to increase with age for a given period in certain species (9, 18, 24).

Part II. The Degree of Crystallinity of Pulp and Holocellulose From Reaction Wood as Compared to That From Normal Wood: The crystallinity of pulp and holocellulose of reaction wood as compared to that of normal wood is shown in Table 4. Analysis of variance (Table 5) shows that crystallinity of compression wood pulp and holocellulose is significantly lower than that of normal wood, while crystallinity of tension wood is significantly higher than that of normal wood in the form of both pulp and holocellulose. These are discussed separately below.

Table 4.—CRYSTALLINITY OF REACTION WOOD FROM COTTONWOOD AND DOUGLAS-FIR COMPARED WITH THAT FROM NORMAL WOOD

Replication	Crystallinity index —X-ray method A— (wood pulp)				Crystallinity ratio —X-ray method B— (holocellulose)			
	C-T*	C-N	D-N	D-C	C-T	C-N	D-N	D-C
1	67.8	55.4	54.9	47.5	57.74	54.55	53.84	52.86
2	66.2	54.8	54.1	46.5	57.71	54.35	53.79	52.41
3	65.8	54.8	53.9	45.2				
av.	66.6	55.0	54.3	46.4	57.73	54.45	53.82	52.64

*C-T—cottonwood tension wood; C-N—cottonwood normal wood; D-N—Douglas-fir normal wood; D-C—Douglas-fir compression wood.

The low crystallinity of compression wood pulp and holocellulose might be expected in view of the lower alpha-cellulose content and lower strength value observed in compression wood. The correlations of these properties with low degree of crystallinity are shown in Table 1. Moreover, a comparison of properties of compression and juvenile wood with normal, mature wood shows that both juvenile wood and compression wood have a lower cellulose content, tracheid length, and tensile strength, and higher fibril angle, longitudinal shrinkage, and lignin content. Thus compression wood may be considered more 'juvenile' than normal wood of the same age and, under this assumption, it may behave like juvenile wood to give a lower crystallinity.

The high degree of crystallinity of cellulose found in tension wood as compared with that from normal wood is in good agreement with the work of Wardrop and Dadswell (4, 19, 20, 21). These men attribute the high degree of crystallinity to the additional gelatinous layer, which is unlignified and contains cellulose in a highly crystalline state.

Since tension wood consists of cellulose of high crystallinity, it should possess all the characteristics of highly crystalline cellulose given in Table 1. There are several deviations from this theoretical expectation, however: ab-

Table 5.—ANALYSIS OF VARIANCE OF CRYSTALLINITY DATA IN TABLE 4

Source of variation	D.F.	S.S.	M.S.	F	
(A) Crystallinity index (wood pulp)					
Replication	2	4.535	2.268	11.691	**
Type of wood	3	623.062	207.687	1070.552	***
Error	6	1.165	0.194		
Total	11	628.762			
(B) Crystallinity ratio (holocellulose)					
Replication	1	0.067	0.067	3.526	N.S.
Type of wood	3	28.506	9.502	500.114	***
Error	3	0.056	0.019		
Total	7	28.629			

Significant at 1 percent level; * Significant at 0.1 percent level; N.S. Non-significant.

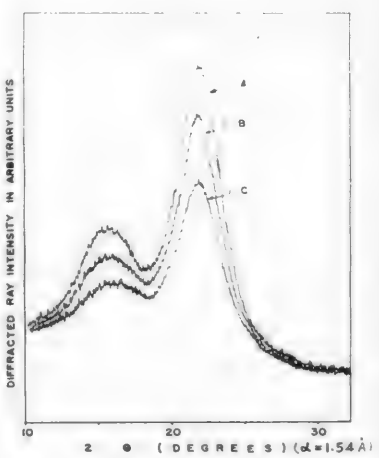


Fig. 3.—X-Ray diffraction spectra of Douglas-fir holocellulose. A. Decayed normal wood, stage B. B. Decayed compression wood, stage B. C. Compression wood, control.

normally high longitudinal shrinkage, and low strength values for fiber stress at the proportional limit in bending, modulus of rupture, modulus of elasticity, work to the proportional limit, work to ultimate load, and longitudinal shear (5). Tension wood does not exhibit decreased toughness, which is supposed to be lower if crystallinity of cellulose is high (see Table 1). A similar anomaly is found in compression wood, which has a lower crystallinity accompanied by a very low value for toughness.

Even some chemical properties of tension wood are at variance with those expected. For instance, the alpha-cellulose content of tension wood is significantly higher than that of normal wood, whereas the pentosan content is lower (6). Thus some workers have pointed out that the cellulose in tension wood has longer molecular chains than the cellulose in normal wood (6). Nevertheless, the degree of polymerization found in the holocellulose of tension wood was reported to be lower than that of holocellulose from normal wood (4).

It is clear now that a single factor such as crystallinity, which is found to be strongly correlated with physical and chemical properties of cellulose and wood under normal conditions, cannot be applied to explain the behavior of reaction wood without considering the effects of some other factors. Gross anatomical structure also plays a role at least as important as that of the fine structure.

Part III. The Degree of Crystallinity of Holocellulose of Decayed Wood: The variation in the crystallinity ratio of wood holocellulose due to decay is shown in Table 6 and Fig. 2. Some of the X-ray spectra are shown in Fig. 3. Analysis of variance (Table 7) indicates that the effect of both decay and type of wood are clearly significant at the 0.1 percent level. Further analysis shows the following:

(a) Crystallinity of holocellulose is greatly increased due to decay in both normal and reaction wood.

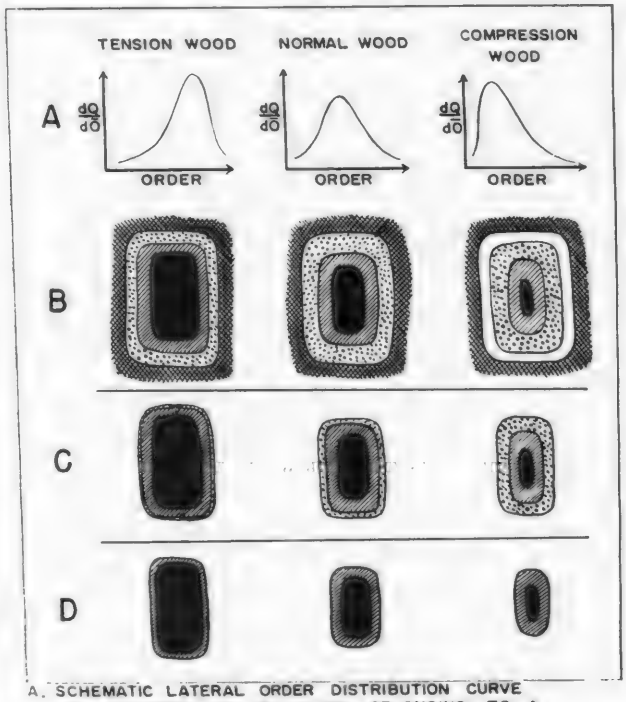
(b) The relative magnitude of increase in crystallinity is approximately identical for each type of wood. Thus the order of crystallinity after decay remains the same as that of the controls. The order of crystallinity of different types of decayed wood depends mainly on the initial crystallinity of wood rather than on the history of decay.

(c) The rate of increase in crystallinity is rapid in the early stage of decay, represented by a 6 percent weight loss. It levels to almost constant crystallinity thereafter except in compression wood, where crystallinity is still increasing at a slower rate to stage B, represented by a 15 percent weight loss. In this latter case, the increase is statistically significant.

It has been shown that the initial enzymatic reaction starts from the amorphous region in the case of enzymatic degradation of cellulose (3, 11, 12, 17). This preference is believed to be the most probable factor resulting in the rapid increase in crystallinity during the earlier stage of decay observed in this study. The increase in crystallinity may be attributed to either or both of the following factors: (a) removal of the amorphous materials, and (b) recrystallization during the preparation of the cellulose specimen used for determination of crystallinity. Recrystallization is quite possible because the free ends of the broken chains on the surface of the crystallite always tend to arrange themselves for recrystallization.

As the decay progresses, the enzymes will gradually reach the crystalline region, which is relatively inaccessible to chemical reaction, and highly resistant to enzymatic hydrolysis. The rate of increase in crystallinity will slow down and finally level off as shown in stage B, Fig. 2.

As previously indicated, the arrangement of various types of wood in order



A. SCHEMATIC LATERAL ORDER DISTRIBUTION CURVE
$\frac{dQ}{dO}$ = QUANTITY OF CELLULOSE BELONGING TO A PARTICULAR ORDER
B. CROSS SECTION OF THE CRYSTALLINE REGION OF THE CONTROL
C. DECAY STAGE A (APPROX. 6 PERCENT WT. LOSS)
D. DECAY STAGE B (APPROX. 15 PERCENT WT. LOSS)
LATERAL ORDER ■ ≫ ▨ > ▩ > □ > ■

Fig. 4.—Schematic lateral order distribution curve and sequence of enzymatic attack on the crystalline region.

Table 6.—CRYSTALLINITY RATIO OF HOLOCELLULOSE OF DECAYED WOOD FROM COTTONWOOD TENSION WOOD AND DOUGLAS-FIR COMPRESSION WOOD COMPARED WITH THAT FROM NORMAL WOOD

Type of wood	Replication	Control	Decay, stage A	Decay, stage B
Cottonwood tension wood	1	57.74	59.70	59.56
	2	57.71	59.50	59.70
	av.	57.73	59.60	59.63
Cottonwood normal wood	1	54.35	55.95	55.90
	2	54.55	55.83	56.17
	av.	54.45	55.89	56.04
Douglas-fir normal wood	1	53.84	54.50	54.65
	2	53.79	54.71	54.59
	av.	53.82	54.61	54.62
Douglas-fir compression wood	1	52.41	53.17	53.77
	2	52.86	53.46	53.88
	av.	52.64	53.32	53.83

Table 7.—ANALYSIS OF VARIANCE OF CRYSTALLINITY RATIOS IN TABLE 6

Source of variation	D.F.	S.S.	M.S.	F	
Unit:					
replication	1	0.061	0.061	2.179	N.S.
type of wood	3	111.009	37.003	13215.000	***
error	3	0.083	0.028		
Subunit:					
treatment	2	8.911	4.456	278.500	***
t x w	6	1.198	0.200	12.500	**
error	8	0.125	0.016		
Total	23	121.387			

**Significant at 1 percent level; ***Significant at 0.1 percent level; N.S. Non-significant.

of decreasing crystallinity of holocellulose is tension wood, normal wood, and compression wood. These differences in crystallinity can be represented by the schematic lateral-order distribution curve illustrated by Howsmon and Sisson (13). Postulated curves obtained in this way are shown in Fig. 4A. The high crystallinity of tension wood is characterized by a negatively skewed distribution curve, whereas the low crystallinity of compression wood is characterized by a positively skewed distribution curve. To correlate the sequence of enzymatic attack with the variation in crystallinity, the lateral-order distribution curves have been transformed into two-dimensional diagrams as shown in Fig. 4B. The lateral order is assumed to be highest at the central portion of the crystalline region, and to decrease gradually toward the surface of the crystallite. Thus the highly crystalline tension wood possesses a relatively small area of low lateral order at the surface of the crystalline region, while the weakly crystalline compression wood has a larger area of low lateral order at the surface of the crystallite. No definite borderline actually exists between each phase of lateral order, so that the transition of lateral order should be regarded as continuous.

As enzymatic hydrolysis begins, the outermost area of low lateral order, which corresponds to the amorphous region, will be dissolved away quickly, thereby leaving the relatively high lateral-order portion (see Fig. 4C). Consequently, the degree of crystallinity of cellulose increases rapidly at this stage, as shown in Fig. 2. Since the relative area of the high lateral-order portion is not changed through successive stages of decay, as shown in Fig 4D, the order of degree of crystallinity can be expected to remain the same as in the controls.

When all readily accessible cellulose is dissolved and decay advances from stage A to B, enzymatic attack still proceeds, but presumably at a slow rate, and only at the surface of the crystallite (17). Hence, the rate of increase in crystallinity will be negligible at this stage, as demonstrated by the present experimental results.

As mentioned above, crystallinity of compression wood holocellulose increased continuously throughout stage B. This can be explained by its abnormally low lateral order, as illustrated in Fig. 4B. At stage A, there is still a considerable amount of relatively low lateral-order material left on the crystallite surface of compression wood (see Fig. 4C). The enzymatic attack continues to proceed at a fast rate, and allows the crystallinity to increase as shown in Fig. 2 and 4D.

Conclusions

1. Crystallinity of wood pulp and holocellulose of the normal western hemlock wood sampled increased significantly through successive growth rings from the pith to about 15 years, after which it reached a more or less constant value.

2. Crystallinity of wood pulp and holocellulose of summerwood from western hemlock wood sampled was significantly higher than that from springwood.

3. Crystallinity of wood pulp and holocellulose of the Douglas-fir compression wood specimens was considerably lower than that of normal wood, whereas crystallinity of wood pulp and holocellulose of the tension wood samples of cottonwood was significantly higher than that of normal wood.

4. The abnormal physical and chemical properties of reaction wood suggest that crystallinity is not the only factor which affects reaction wood properties. There must be other factors responsible for the properties of reaction wood.

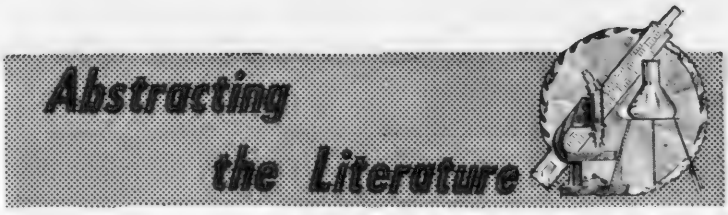
5. Crystallinity of cottonwood and Douglas-fir holocellulose increases significantly during decay caused by the brown-rot fungi, *Poria incrassata* and *Poria monticola.*

6. The rate of increase in crystallinity due to decay is rapid during the incipient stage of decay represented by 6 percent weight loss, but becomes very slow and shows almost a constant value of crystallinity thereafter. In the case of compression wood, the crystallinity increases through the stage of decay represented by 15 percent weight loss, but at a rate slightly lower than that for the earlier stage of decay.

7. The order of degree of crystallinity for various woods after decay is the same as the controls, that is, tension wood exhibits the highest and compression wood the lowest value of crystallinity. The relative value of crystallinity after decay depends mainly upon the initial crystallinity rather than the history of decay.

Literature Cited

1. Anker-Rasch, O. and J. L. McCarthy. 1954. Behaviour of celluloses in sodium hydroxide solutions. Norsk Skogindustri 10: 329–33.
2. Ant-Wuorinen, O. 1955. Evaluation of the crystallinity of cellulose from X-ray diffraction pictures. Finland. The State Institute for Technical Research. Rept. 146. 82 pp.
3. Bailey, I. W. 1954. Contributions to plant anatomy. Chronica Botanica Co. Waltham. 258 pp.
4. Bolam, F. (ed.) 1958. Fundamentals of papermaking fibres. British Paper and Board Makers' Association, England. 487 pp.
5. Brown, H. P., A. J. Panshin, and C. C. Forsaith. 1952. Textbook of wood technology, Vol. II. McGraw-Hill Book Co., Inc., New York. 783 pp.
6. Chow, K. Y. 1946. A comparative study of the structure and chemical composition of tension wood and normal wood in beech *(Fagus sylvatica L.)* Forestry 20: 62–77.
7. Conrad, C. C., and A. G. Scroggie. 1945. Chemical characterization of rayon yarns and cellulosic raw materials. Ind. Eng. Chem. 37: 592–598.
8. Holzer, W. F. and H. F. Lewis. 1950. The characteristics of unbleached kraft pulp from western hemlock, Douglas fir, western red cedar, loblolly pine and black spruce. VII. Comparison of springwood and summerwood fibers of Douglas fir. Tappi 33(2): 110–112.
9. Kennedy, R. W., and J. M. Jaworsky. 1960. Variation in cellulose content of Douglas fir. Tappi 43(1): 25–27.
10. Lindgren, P. H. 1958. X-ray orientation investigations on some Swedish cellulose materials. Arkiv för Kemi 12 (38): 437–452.
11. Norkrans, B. 1950. Influence of cellulolytic enzymes from hymenomycetes on cellulose preparations of different crystallinity. Physiologia Plantarium 3: 75–87.
12. Norkrans, B., and B. G. Ranby. 1956. Studies of the enzymatic degradation of cellulose. Physiologia Plantarum 9: 198–211.
13. Ott, E., H. M. Spurlin and M. W. Graffin. (eds.) 1954. Cellulose and cellulose derivatives. Part I. 2nd ed. Interscience Publ. Inc., New York. 509 pp.
14. Preston, R. D., P. H. Hermans and A. Weidinger. 1950. The crystalline—non-crystalline ratio in cellulose of biological interest. J. Exp. Bot. 1: 344–352.
15. Ritter, G. J., and L. C. Fleck. 1926. Chemistry of wood. IX. Springwood and summerwood. Ind. Eng. Chem. 18: 608–609.
16. Taniguchi, E. 1956. XIV. Variations of fine structure in *Pinus densiflora* and *Phyllostachys edulis* through their growth. J. Jap. Wood Res. Soc. 2: 152–157, Chem. Abst. 51: 9145.
17. Walseth, C. S. 1954. The influence of the fine structure of cellulose on the action of celluloses. Tappi 35(5): 233–238.
18. Wardrop, A. B. 1951. Cell wall organization and the properties of the xylem. I. Cell wall organization and the variation of breaking load in tension of the xylem in conifer stems. Aust. J. Sci. Res. B4: 391–414.
19. Wardrop, A. B. 1956. V. The distribution and formation of tension wood in some species of Eucalyptus. Aust. J. Bot. 4: 152–166.
20. Wardrop, A. B., and H. E. Dadswell. 1948. The nature of reaction wood. Aust. J. Sci. Res. B1: 3–16.
21. Wardrop, A. B., and H. E. Dadswell. 1955. The nature of reaction wood. IV. Variations in cell wall organization of tension wood fibers. Aust. J. Bot. 3 (2): 177–189.
22. Wise, L. E. (ed.) 1946. Wood Chemistry. Reinhold Publ. Co., New York. 900 pp.
23. Wise, L. E., M. Murphy and A. A. D'Addieco. 1946. Chlorite holocellulose, its fractionation and bearing on summative wood analysis and on studies on the hemicelluloses. Paper Trade J. 122(3): 35–43.
24. Zobel, B. J., and R. C. McElwee. 1958. Variation of cellulose in loblolly pine Tappi 41(4): 167–170.
25. Zobel, B., C. Webb, and F. Henson. 1959. Core or juvenile wood of loblolly and slash pine trees. Tappi 42 (5): 345–356.



PARTICLE BOARD

Petri, V. N., and Permikin, I. P. The use of petrolatum in the manufacture of wood-particle board. Derevoobrabat. Prom. no. 12: 11–12 (1959); Referat. Zhur., Khim. no. 12: 741 (1960). [Russ. Abstr. only available]

In the mfr. of wood-particle board, paraffin as a waterproofing agent is replaced by petrolatum. A description is given of the pressing method, and of the results of tests on boards made of sawdust, MF–10 resin, and petrolatum, and also on boards contg. residual sulfite fermentation liquor as binder. (A.B.I.P.C. 31:5)

PARTICLE BOARD

Shorygina, N. V., Kurochkina, G. L., and Kozel'tsev, L. I. A resin based on the total phenolic fraction, and its use in the manufacture of wood-particle board. Stroit. Materialy no. 12: 22–4 (1959); Referat. Zhur., Khim. no. 12: 741 (1960). [Russ. Abstr. only available]

KF-20 resin is prepd. from the phenolic fraction extd. from coal coking prods. Its optimum polymerization temp. is 140–145° C. However, wood-particle board contg. this resin can be pressed at 110–120°. Before mixing with wood-paste particles, 3–5% of a kerosene prepn. is added to the resin. Lab. tests on exptl. boards having densities of 300, 600, and *ca.* 900 kg./cu.m., showed that their mech. props. are similar to those of wood-particle board based on PF resins (A.B.I.P.C. 31:5)

TRANSPIRATION STREAM IN TREES

Postlethwait, S. N., and Rogers, Bruce. Tracing the path of the transpiration stream in trees by the use of radioactive isotopes. Am. J. Botany 45: 753–7 (Dec. 1958).

The movement of radioactive phosphorus and iodine, applied in a 0.1 *N* soln. of potassium chloride directly to the tree trunk 3 ft. above the ground, was traced in shagbark hickory *(Carya ovata)*, red pine *(Pinus resinosa)*, and blue beech *(Carpinus caroliniana)*. The radioactive soln. was applied in August, October, March, and June to intact trees and to trees in which the water columns had been severed by deep cuts distributed in different patterns around the trunk. These expts. corroborated the findings of several authors that water can move up a tree in which all direct water columns have been severed. The radioactive isotopes moved around the cuts within 24 hr. after appln. in a manner suggesting that the living xylem elts. are responsible for the water transport. The lack of movement of isotopes in one exptl. series, when they were applied in March, can be explained by the lack or very slow rate of transpiration during the dormant season. A direct vert. movement was observed in all trees with intact water columns. 9 ref. (A.B.I.P.C. 31:5)

STRUCTURE OF SPRUCE

Odintsov, P., and Erin'sh, P. The capillary structure of wood and holocellulose (as determined) from sorption isotherms of benzene vapors. Latv. P.S.R. Zinatnu Akad. (Izvest. Akad. Nauk. Latv. S.S.R.) no. 11: 115–22 (1959); Referat. Zhur., Khim. no. 12: 647–8 (1960). (Russ.; Engl. sum. Abstr. only available).

As detd. from sorption isotherms of benzene vapor, the internal surface of sprucewood and spruce holocellulose is 300 and 450–500 sq. m./g., resp. Pores having a radius of 30–1000 A. are almost completely absent in sprucewood. In holocellulose, pores having a radius of 15–80 A. predominate. The 30–1000 A. pores are formed after removal of lignin from wood. The vol. distribution curve of holocellulose has a max. at a radius of 17–18 A. There is no shift of the max. after contraction of the capillaries. During contraction of the capillary structure of holocellulose, the vol. of pores having a radius of 19–80 A. decreases considerably, but the vol. of the 17–18 A. pores is only insignificantly reduced. Partial removal of hemicellulose from the holocellulose causes an increase in the vol. of pores having a radius of over 200 A. (A.B.I.P.C. 31:5)

WOOD-BASED PLASTIC

Varaksin, F. D. Wood-based plastic without binder. Derevoobrabat. Prom. no. 11: 7–10 (1959); Referat. Zhur., Khim. no. 12: 741 (1960). [Russ. Abstr. only available]

A plastic matl. was obtained from milled wood by piezo-thermal trmt. in a tightly closed pressing mold. Under high pressures, the vol. of the milled wood decreases 8–10 times. To perform the process in one stage, either large pressing molds must be used, or the wood must be pretrd. by preliminary pressing. This can be done in cold presses, or at 40–50° C. The preliminary pressing reduces the wood vol. 4.5–5 times. The hydraulic pressure and the temp. and time of pressing affect the mech. props. of the wood plastic. Thus, the water absorption of the plastic is considerably reduced by increasing the pressure to 150 kg./sq. cm., and reaches its min. at pressures of of 300 kg./sq. cm. A considerable increase of mech. strength and d., and a redn., of water absorptivity are observed at 150–200°. The hardness of the matl. increases with time of pressing. It has a high bending strength at a pressing time of 1 min./mm. The quality of the prod. is also detd. by the degree of airtightness and thermal insulation of the presses. Preliminary trmt. of the raw matl. with dil. acids, such as sulfuric aicid, makes it possible to mfr. the binderless wood plastic at 150–160° under a pressure of 40–50 kg./sq. cm. without the use of costly pressing molds. (A.B.I.P.C. 31:5)

WOOD HYDROLYSIS

Chalov, N. V., Goryachikh, E. F., and Leshchuk, A. E. A new procedure for the hydrolysis of wood with concentrated hydrochloric acid. Gidroliz. i Lesokhim. Prom. 12, no. 3: 3–5; no. 4: 1–4 (1959). [Russ.]

The process of wood saccharification with concd. hydrochloric acid, devd. by the author, is a modification of the Bergius process and is carried out in a 6-diffuser unit. In one diffuser, the hemicellulose components are hydrolyzed (by means of steeping in a liquor contg. prods. of partial hydrolysis and hydrochloric acid of reduced concn.), in two others the cellulose component is hydrolyzed with 41% hydrochloric acid, and in two the hydrogen chloride is washed off from the residual lignin with water; the sixth diffuser is either loaded with chips or unloaded while the other five are in operation. The process is continuous and involves a 12-hr. cycle, one diffuser remaining disconnected in each cycle for loading or unloading operations and one for the stationary hydrolysis of hemicelluloses. The process has been introduced at the Kansk hydrolysis plant for the saccharification of pinewood chips. Tests carried out on a lab. model of the 6-diffuser equipment confirmed the results obtained previously in expts. which led to the devt. of the process, viz., that hemicelluloses are completely hydrolyzed during the 12-hr. steeping period and that a 12-hr. action of 41% hydrochloric acid is sufficient to hydrolyze cellulose completely. The hydrolyzate contained 21.17% sugars and 30.22% hydrogen chloride. On the basis of o.d. wood, the yield of sugars was 68.27%, i.e., 99.8% of theoretical. The residual lignin contained 85% moisture. The water drained from the lignin contained 0.1–0.15% hydrogen chloride. 4 ref. (A.B.I.P.C. 31:4)

HYDROGENATION

Vasyunina, N. A., Balandin, A. A., Chepigo, S. V., and Barysheva, G. S. Catalytic hydrogenation of wood and other plant materials. Izvest. Akad. Nauk S.S.S.R., Otdel. Khim. Nauk no. 8: 1522–3 (Aug., 1960). [Russ.] *cf.* A.B.I.P.C. 31: abstr. 1497–8.

A method for the prepn. of polyols and phenols from wood and other plant matls. comprises hydrolytic hydrogenation of polysaccharides in an acid medium, followed by hydrogenation of lignin in an alk. medium. The same ruthenium catalyst is used in both stages. The matl., such as pinewood meal, is heated 45–60 min. at 160–170° C. and 30–50 atm. initial hydrogen pressure with phosphoric acid in the presence of the ruthenium catalyst. The catalyzate is sepd. from lignin, passed through an anion ex changer, and evapd. in vacuum. The yield of penta- and hexahydric cryst. alcs. is 95%, based on wood polysaccharides. The residue is heated for 2–2.5 hr. with 1.5% aq. sodium hydroxide at 280–320° under a hydrogen pressure of 50–70 atm. The colorless catalyzate yields about 35% phenols based on lignin wt. Phenol, *m*-cresol, and pyrocatechol were identified by chromat. 2 ref. (A.B.I.P.C. 31:5)

WOOD RESIN TURPENTINE

Bardyshev, I. I., and Efimenko, E. I. Alterations of the properties of wood resin turpentine during heating in the presence of rosin. Nauch. Doklady Vyssh. Shkoly, Lesoinzh. Delo no. 2: 215–17 (1959); Referat. Zhur., Khim. no. 11: 483 (1960). [Russ. Abstr. only available]

When turpintine is heated in the presence of rosin at 170–190° C., its qualitf is improved. More particularly, there is an increase in yield of the fraction boiling below 170°. The max. vol. of this fraction is obtained by heating for 0.5–1 hr. The heating results in an increased content of α-pinene, formed by isomerization of β-pinene. Also, there is an increase in the optical rotation of turpentine, attributed to the formation of camphene. If turpentine is heated with rosin at higher temp., its quality is lowered. At 200–205°, there is a considerable redn. in the vol. of the fraction boiling 170°, and at 210–212° the deterioration is rapid. A study of the isomerization of turpentine components bave the fig. results: During 1 hr. heating at 170–180° in the presence of rosin, 26% of β-pinene undergoes isomerization; at 200–205°, 75% isomerizes, α-Pinene constitutes 84–93% of the isomerization prods. Other prods. are dipentene, limonene, camphene, β-myrcene, *allo*-ocimene, polymeric cpds., and probably terpinolene. Δ^3-Carene appears to be quite stable: it does not isomerize even upon prolonged heating at 170–180° in the presence of rosin. (A.B.I.P.C. 31:5)

RESIN STUDIES

Nyren, Vera, and Back, Ernst. The resin in parenchymatous cells and resin canals of conifers. VI. Characteristics of parenchymatous cells and tracheidal ray cells in *Picea abies* Karst. Svensk Papperstidn. 63, no. 16: 501–9 (Aug. 31, 1960). [Engl.; Swed. and Ger. sum.] *cf.* A.B.I.P.C. 30: p 811.

The characs. and identifying features are reported for the tracheidal and parenchymatous ray cells, the vert. parenchyma, strand tracheids, epithelial cells, and pith cells of *Picea abies* Karst. *(Picea excelsa* L.*)* pulpwood grown at 59–61° northern latitudes. In *Picea abies,* only one type of parenchymatous ray cells appears. They are thick-walled and their rel. pit area is estd. to be as low as 5% compared to 50% found for *Pinus sylvestris.* This appears to be one of the reasons for the rel. slower alk. deresination of sprucewood pulps. Besides being rather small, the pits are of the so-called piceoid type. Observations are collected to interpret the formation of such piceoid pits in parenchyma cells, which are characd. by a substantial primary and a heavy secondary wall. The tracheidal ray cells of *Picea abies* also show less variation in form and appearance than those of *Pinus sylvestris.* Their frequency relative to that of ray parenchyma cells is only 1:2.7, as compared to the corresponding frequency of 2.8:1 for *Pinus sylvestris.* Vert. parenchyma cells are thick-walled and similar to ray parenchyma. They appear at the vert. resin canals as a few cell rows only, without forming a complete layer around these canals. Occasionally there appears at these canals a vert. cell row of short so-called strand tracheids. The epithelial cells are rather thick-walled. 16 ref. (A.B.I.P.C. 31.5)

HARDBOARDS

Osterberg, Lars, Brauns, Otto, and Back, Ernst. The one-sided water and oil absorption of hardboards. Svensk Papperstidn. 63, no. 19: 658–64 (Oct. 15, 1960). [Swed.. Engl. and Ger. sum.]

An app. has been devd. for one-side water and oil absorption measurements of hardboard according to the Cobb method. The necessary seal between the liquid and the hardboard specimen is obtained by a sharp edge on a short cylinder, attached to a stiff cast iron housing, which can be pressed against the specimen with considerable force by the use of two eccentrics. The open construction of the app. permits the removal of the surplus liquid by blotting directly in the app., which reduces the variance esp. when testing with viscous liquids. For std. tests on a hardboard area of 1 sq. dm. at 20° C., a contact time of 2 hr. is used for water and 3 min. for a mineral oil of 3.00 cp. viscy. The over-all coeff. of variation for several specimens from a single hardboard sheet has been 3% for one-side water absorption and 9% for one-side oil absorption. As has been shown for other matls., the amt. of absorbed liquid increases linearly with the square root of the absorption time, disregarding a short wetting period. For chemically similar mineral oils the absorption is proportional to the inverse of the square root of the viscy. In regard to capillary structure hardboard is considerably anisotropic. For a mineral oil the penetration depth per square root of the absorption time is thus four times larger in the plane of the hardboard sheet than perpendicular to this plane. In the beginning of the heat trmt., the one-side water absorption of hardboard falls off quickly. It is notable that the water absorption is larger on the smooth side than on the wire side before heat trmt., whereas the contrary is true after heat trmt. The oil absorption of hardboard is usually increased by heat trmt. By measuring the one-side water absorption, as well as the water absorption at total immersion, the absorption through the sawn edges has been detd. for a few hardboards. The av. rel. absorption through the sawn edges was 20% for test specimens of 15 by 15 cm. and an absorption time of 2 hr. at 20°. 11 ref. (A.B.I.P.C. 31:5)

SLASH PINE, SWEET GUM

Jurbergs, K. A. An electron microscope study: slash pine and sweetgum fibers. Tappi 43, no. 10: 865–71 (Oct., 1960).

Electron microscopic techniques have been appl. to investigating the structure of pulp fibers from slash pine *(Pinus elliottii)* and sweetgum *(Liquidambar styraciflua).* The evidence obtained from both wood sp. indicates that the primary wall is removed during the prodn. of dissolving-grade pulps. The surface of the outer layer of the secondary wall which covers the fibers consists of two systems of fibrils crossing each other at an angle of about 140°. Two systems of fibrils crossing in wide arcs have also been found on the surface of the pine-bordered pit cavities. The pit annulus appears as a sep. structure, possibly consisting of lignin. The torus consists of a circular primary part with secondary thickenings. Several of the perforated pit closing membranes found are believed to belong to the semibordered type from ray crossfields. 7 ref. (A.B.I.P.C. 31:5)

PULP AND PAPER PROPERTIES

Colombo, P., Corbetta, D., Pirotta, A., and Ruffini, G. Effects of mechanical chips treatment on pulp and paper properties for kraft cooking of softwood. Syensk Papperstidn. 63, no. 15: 457–71 (Aug. 15, 1960). [Engl.; Swed. and Ger. sum.]

To study the effect of chip size on the pulp produced by kraft cooking, a batch of chips was screened into five fractions with decreasing dimensions. Small-scale lab. expts. showed that the chem. props. of the pulps produced were widely different. By trg. the first three fractions with a roller press it was possible to reduce the differences within reasonable limits. The operation of the roller press to produce chips of uniform size is explained. When the expts. were repeated on a com. scale, the previous results were confirmed: Untrd. fractions presented large differences in yield, percentage of rejects, and lignin content of the pulps. Treated fractions showed a consistent uniformity in chem. props., higher selectivity of the cooking process, and higher yield at the same lignin content or lower lignin content at the same yield. Paper props. for trd. fractions were at least as good as for untrd. fractions. In a final set of expts., in which mixts. of trd. and untrd. fractions were cooked, the results were again in favor of press trmt. of the biggest chips. Possible applns. to com. prodn. are discussed. 17 ref. (A.B.I.P.C. 31:5)

FIBER BOARDS

Helge, Kjell. Investigations of yield and quality of insulating fiber building boards manufactured of different qualities of wood. Norsk Skogind. 14, no. 9: 330–7 (Sept., 1960). [Norw.; Engl. sum.]

An account is given of research work concerning the suitability of different qualities of wood as raw matl. for the mfr. of insulating fiber building boards. The expts. cover lab. defiberizing of dry (stored) slabs of spruce, as well as green slabs of birch, pine, and spruce. The use of dry (stored) wood has an unfavorable influence on yield as well as on board quality. The difference in yield between the wood sp. investigated increases with increasing preheating time. The strength props. of boards made from green wood are better than those of boards prepd. from dry wood, and an increase in preheating time causes an increase in the difference between green and stored wood. The drop in strength props. resulting from an increase in preheating time is considerably less when chips of green wood are used than when chips of dry wood are used. Pulp prepd. from dry wood requires different refining or grinding conditions than does pulp made from green wood, if a short preheating time has been used. With increased preheating time this effect becomes less noticeable. Birch cannot be considered as a suitable raw matl. in the mfr. of insulating board without further pretmt. When defiberizing a mixt. of spruce and birch chips, even a rel. small amt. of birch chips causes a considerable drop in the mech. strength props. of the boards produced. Boards made from pine may have strength props. as good as those made from spruce. However, the pine pulp must be refined to a considerably higher degree of freeness than the spruce pulp; this causes difficulties regarding the drainage time. 2 ref. (A.B.I.P.C. 31:5)

NAMES in the NEWS

Appointment of **M. H. Adelman, J. E. Dannin, Anton Jurecic, G. J. Kollmann,** and **P. J. McGonigal** as research chemists, and **Dr. Albert Malatesta** as a research group leader to the Central Research Laboratories of The Borden Chemical Company, has been announced by **Dr. B. D. Halpern,** Director of Research.

Dr. Joseph A. Fertig has been promoted to supervisor in the Resin Research Group at the Alexander Research and Development Laboratories of National Starch and Chemical Corporation. He has been an important contributor to National's success in developing synthetic polymer systems.

According to **R. A. Bristol,** executive vice president and director of sales of The Foxboro Company, Foxboro, Mass., **Charles Schwarzler** has been named head of the new marketing division; **H. O. Ehrisman** is now vice president and U. S. general sales manager; and **V. V. Tivy** has been appointed director of engineering.

Ward Mayer, Timber Structures, Inc., Portland, has recently been elected chairman of the National Wood Council; **George Curtis,** Curtis Companies, Clinton, Iowa, is vice-chairman, and **Glen Simon,** NLMA, is secretary.

Dr. H. S. Gardner, director of research and development for Fibreboard Paper Products Corporation, Antioch, Calif., has been elected president of the Technical Advisory Council to the University of California's Forest Products Laboratory. **Alfred Smith,** general manager of Union Planing Mill, Stockton, Calif., was chosen to succeed Gardner as vice-president of the Council.

The Diehl Manufacturing Co. has announced the appointment of **E. R. Zeek** as vice president in charge of research and engineering, **G. J. Abel** as vice president of Manufacturing Engineering.

Dr. R. A. Cockrell, professor of forestry and associate dean of the Graduate Division at the University of California in Berkeley, has been awarded a senior visiting fellowship by the Organization for European Economic Cooperation to conduct research on wood structure and anatomy in Germany and Switzerland.

Robert H. LeSage has been promoted to assistant product sales manager of the "POP" Rivet Division of United Shoe Machinery Corp., Shelton, Conn., according to **Henry Tolman II,** manager of the Shelton plant. He succeeds **J. H. Schofield** who was recently elevated to product sales manager.

The election of **W. L. Kauffman** as controller of The Flintkote Co., was reported by **I. J. Harvey, Jr.,** chairman of the board and chief executive officer. Mr. Kauffman, previously assistant controller, succeeds **D. J. McNamara,** who is retiring after 40 years of service with the company.

Henry Harnischfeger, president of Harnischfeger Corporation, Milwaukee, Wis., recently announced important organizational changes: **W. S. Burdick** has assumed the osition of corporate consulting engineer; **Bernard Pratte** has been elected to the position of assistant to the president; **R. D. Teece** is named to the post of vice president of engineering; **W. L. Carter** has been appointed vice president of finance and treasurer; and **D. J. Coyle** is the new plant manager of the Los Angeles manufacturing operations.

Z. A. Zasada, leader at the Grand Rapids, Mich., field unit of the Lake States Forest Experiment Station, has been promoted to staff assistant in Research Administration in the Washington D. C. office of the U. S. Forest Service, **M. B. Dickerman,** Director of the Station has said.

INDEX TO ADVERTISERS

	Page
American Cyanamid Company	2nd cover
American Defibrator, Inc.	2-A
Appleton Machine Co.	9-A
Behr-Manning Co.	1-A
Black Brothers Company, Inc.	16-A
Greenlee Bros. & Co.	6-A
Industron Corporation	4th cover
Koppers Company, Inc.	19-A
Mattison Machine Works	3rd cover
Mereen-Johnson Machine Co.	20-A
National Casein Co.	3-A
Quaker Oats Co.	15-A
Reichhold Chemicals, Inc.	11-A
G. Siempelkamp & Co.	4-A
Soderham Machine Mfg. Co.	17-A
Williams Patent Crusher & Pulverizer Co.	13-A
Wood Treating Chemicals Co.	10-A

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Employment Wanted

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631—Position desired in particle board production or quality control. Four years experience in particle board operation as control technologist and production manager. B. S. Univ. of Minnesota in Forest Products. Prefer North or West. Married, age 27. (Feb.)

632—Want responsible position in forestry. Recent experience has been administrator, policy consultant, and research director. Have also been active in field work, research, mechanical development and teaching. B.S., M.S. Forestry. Married, age 45, three children. (Feb.)

633—Chemist, wood technologist desires responsible position with progressive company manufacturing or contemplating manufacture of wood adhesives. Extensive experience in all types and in all phases including development, sales, and service. Nationally recognized authority on animal and polyvinyl adhesives. (Feb.)

634—Lumber seasoning consultant, research, kiln operator, varied lumber mill; totalling 11½ yrs. experience. Wood Products B.S. 1949 Oregon State College. Seeks position in seasoning, production, quality control. West. (March)

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Item Numbers—February 1961

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	1947–51 Proceedings			

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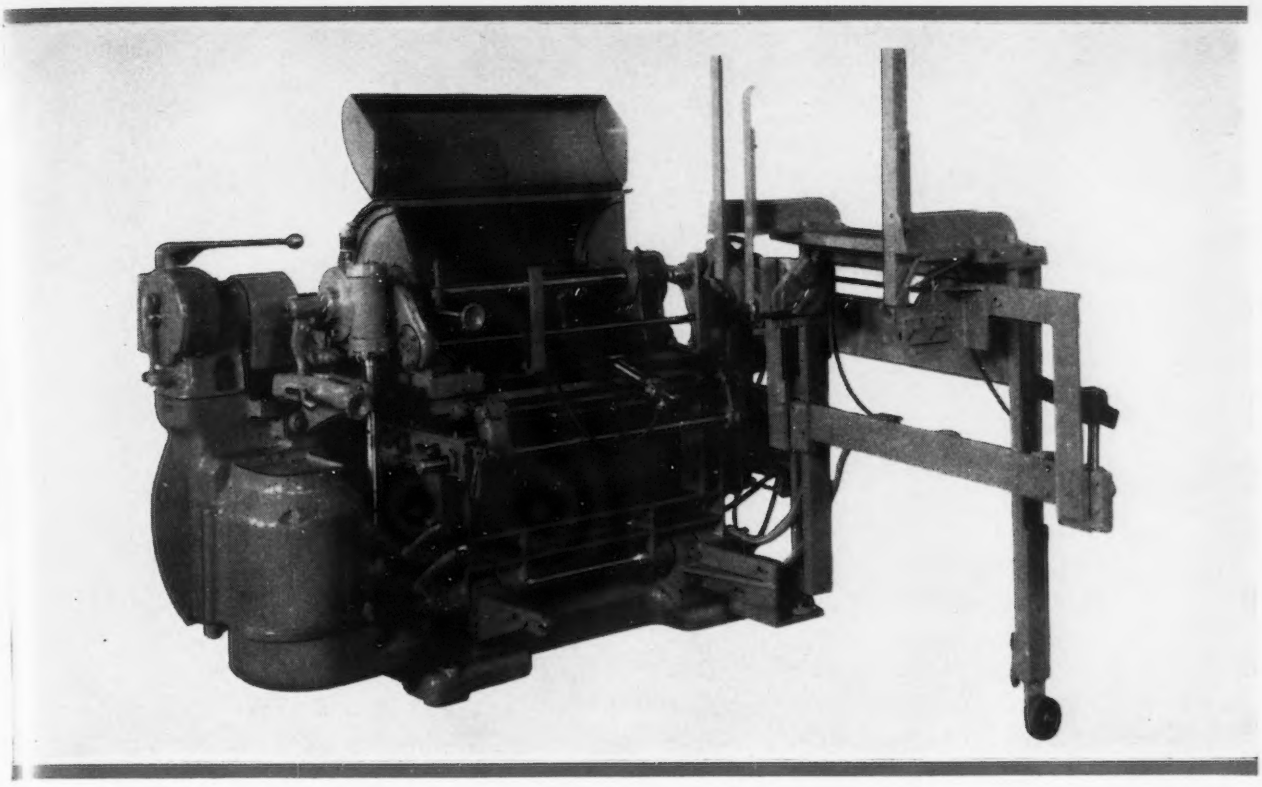

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